AUTOMATION

FEBRUARY 1955
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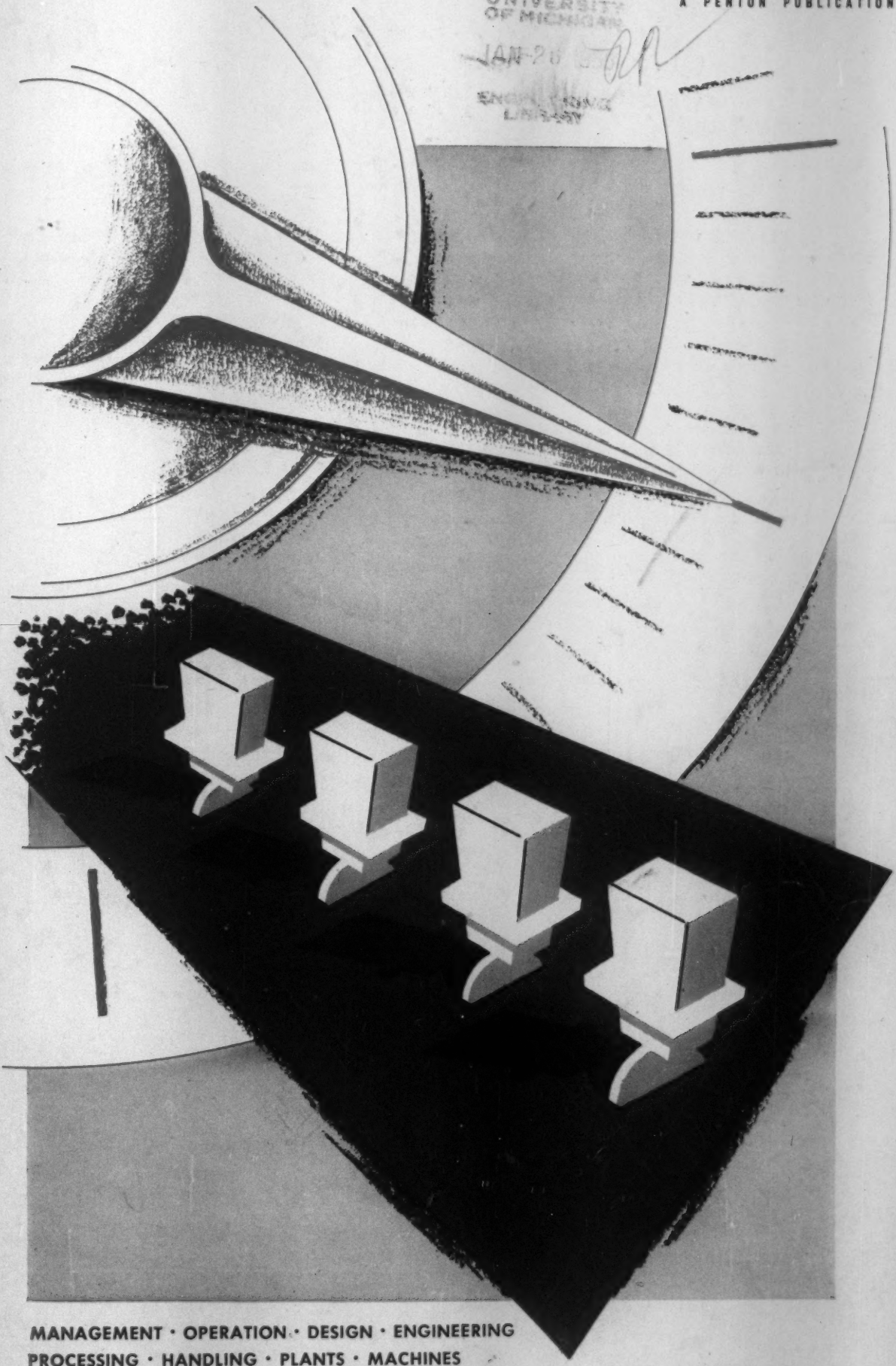

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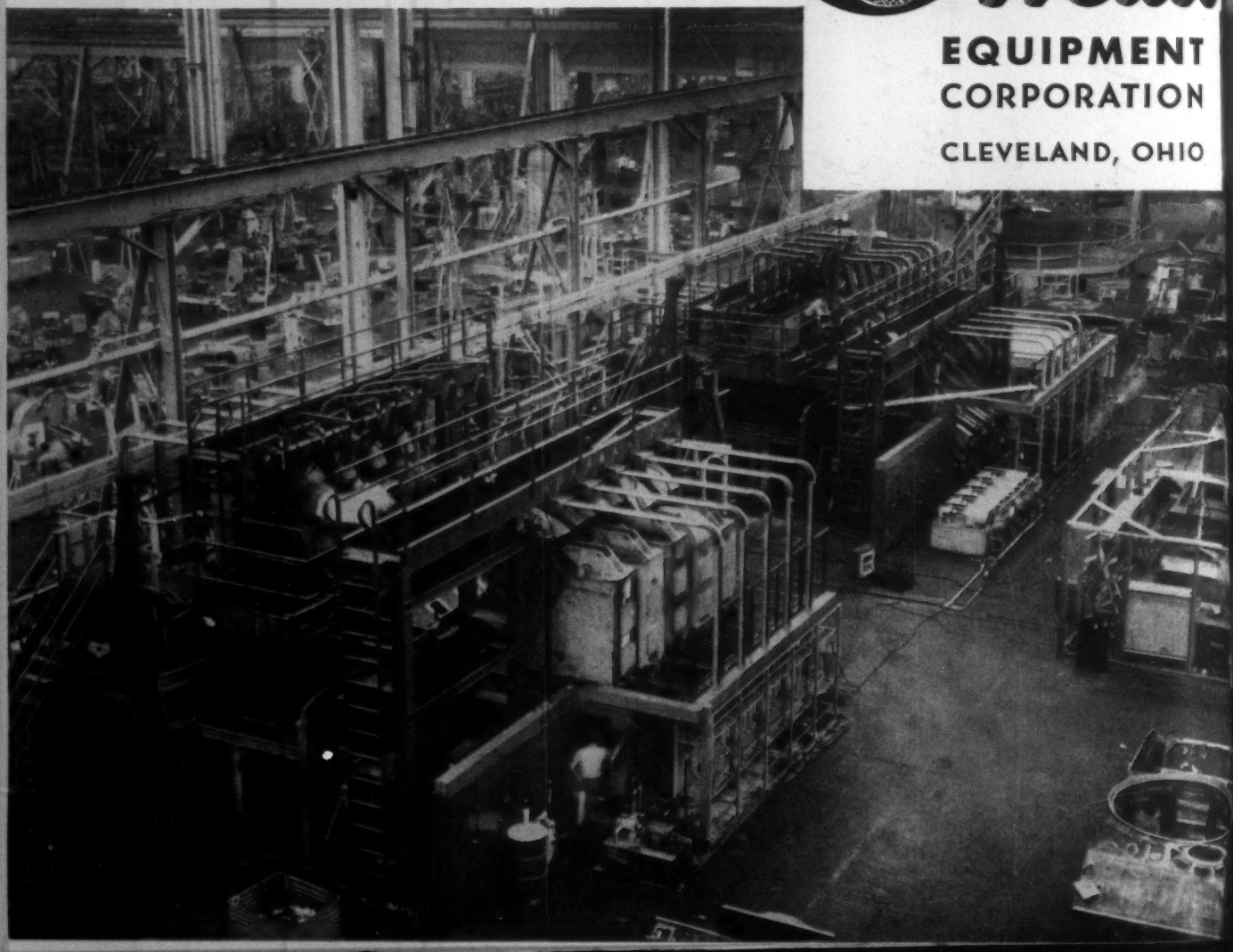

FEBRUARY, 1955
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AUTOMATION

THE MAGAZINE OF AUTOMATIC OPERATIONS

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REGULAR DEPARTMENTS

Automation Outlook, 4
Automation News, 8
New Equipment, 76
New Components, 90
New Literature, 106
Abstracts, 114
Patents, 122
Editorial Index, 124
New Books, 126

Real Advance, 25
EDITORIAL—automation is improving the personal lot of workers in addition to raising the standard of living.

Heavy Material Handling Uses Automation, 26
E. H. ABBE—installations for coal, stone and ore have accurate sequencing and closed cycle control.

Fabricating Television Circuits, 31
AUTOMATION TODAY—new machine automatically assembles parts to printed circuit boards.

Management Of Systems Engineering, 35
E. D. GITTENS—part one—applying large groups of variously specialized engineers presents a new challenge.

Gaging For Process Control, 42
ALBERT C. SANFORD—part three—gaging machines sort parts, signal unacceptable percentages of rejects.

Continuous Mining Of Coal, 46
EXTENSIBLE BELT—conveyor system that follows mining machine increases productivity, improves working conditions.

Hydraulic And Pneumatic Servos, 49
R. HADEKEL—part five—analysis of pump and valve servos, involving thorough study of slide valves.

Automatic Bulk Proportioning, 59
REMOTE CONTROL—batch weighing system maintains quality of dry mixed cement products.

Automatic Control Terminology, 61
CONTROLLER ELEMENTS AND CHARACTERISTICS — BASIC TERMS — standard process control terms defined and illustrated.

Continuous Crankshaft Grinding, 62
TRANSFER SYSTEM—loads and unloads successive bearing grinding stations, trues wheels and gages size.

Integrated Data Processing, 65
P. B. GARROTT—part three—guideposts for applying the common language idea to the automation of paperwork.

Screw Conveyors Go Overhead, 73
ONE-WAY CONSTRUCTION—flexible screw has top exposed to propel hooks along supporting rail.

Photocell Automation Sorts By Color, 74
PHOTOELECTRIC DEVICE—segregates items into categories of different hues or relative brightness.

AUTOMATION OUTLOOK

EVERYTHING BUT THINK

". . . but the machine is not all. A machine is a device with which the human being can progress. He can make it do everything *but think*, and he can feed information into it through programming devices, which gives it the *appearance* of thinking. Some devices can be simple and some can be complex. Our fight has been to keep them simple . . ."—*F. E. Wenger, Wright Air Development Center.*

SOLUTIONS TO PROBLEMS

". . . one use of systems engineering which has come dramatically into view in recent years is in the field of automatic controls. Systems engineering, in this particular area, has a range and scope which broadly embraces the design, development, and production of automatic controls for aircraft, industrial processes, communications, ordnance, and navigation—not in terms of automatic machines or devices alone, but as fully co-ordinated solutions to operational problems . . ."—*E. D. Gittens, chief engineer, Arma Div., American Bosch Arma Corp.* *See Page 35.*

THE POSSIBLE AND THE PRACTICAL

". . . giant brains are designed for scientific computation where much complex calculation is based on a relatively small amount of data. These machines are not efficient for most business routines where there is a great mass of data to be handled through the use of fairly simple arithmetic. At every turn we must distinguish between solutions that are possible and solutions that are practical. Most engineers concede that electronics can be made to do almost any clerical job. That is not to say, however, that an electronic device is necessarily the most efficient means of doing it. Indeed, to employ electronics for certain phases of data processing work is rather like the proverbial use of a pile driver on a thumb tack . . ." —*John S. Coleman, president, Burroughs Corp.*

RISING TIDE

". . . I have pointed out how our understanding of automation has expanded from a simple definition involving automatic handling between operations to a concept which has engulfed our planning for all manufacturing processes. This change has taken place in a few short years. We will have increasing opportunities in the future to apply automation in many more of our manufacturing operations . . ."—*D. S. Harder, vice president - manufacturing, Ford Motor Co.*

DESIGNED FOR PRODUCTION

". . . the serious, practical approach to machine assembly is going to call for engineered design of parts which are more practical for manufacture by machine assembly. . ."—*George H. Kendall, Multra Corp.*

THE COMBINATION IS IMPORTANT

". . . automation is not simple mechanization such as a coal breaker. As soon as we add transfer devices to a breaker, for instance, a feeder conveyor and a discharge conveyor, the combination of the three becomes automation . . ."—*E. H. Abbe, Industrial Control Dept., General Electric Co.* *See Page 26.*

THE GROWING LEGIONS

". . . automation, reaching maturity after some 15 years in industry, is spreading into the last plants—still taking on more and more of the muscle-straining jobs once done by sweating men. But there are *no robots* in the plants. The industry is employing growing legions of engineers, technicians, and skilled operators, and maintenance men, but no robots . . ."—*Automobile Facts.*

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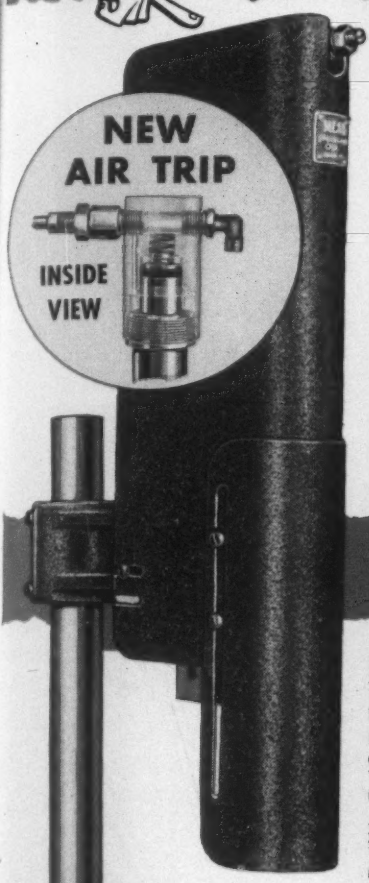

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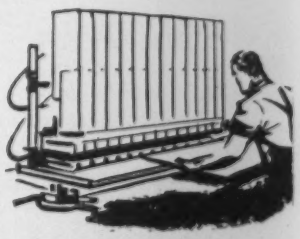

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AUTOMATION NEWS

Today's events and developments of importance in the field of modern automation

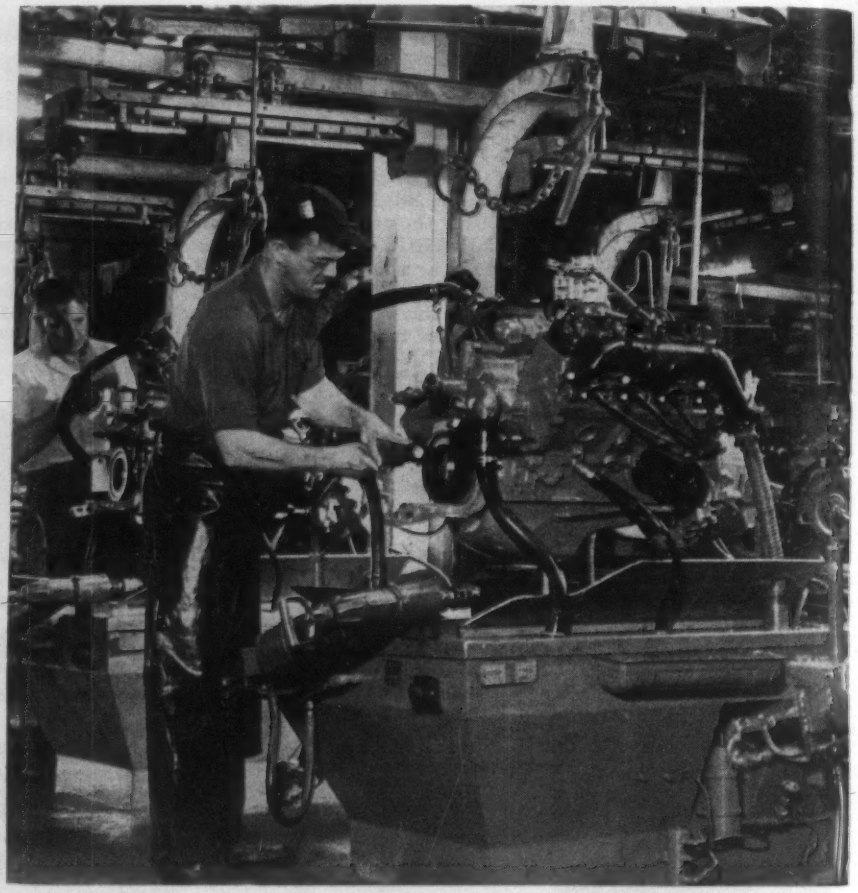
Automation in Action

NEWEST facility of Ford Motor Co. is the Dearborn engine plant, operated by the company's Engine and Foundry Division. It contains 1,500,000 square feet of floor space, employs approximately 8,000 people, and is equipped with the latest in automation devices and machine tools.

Automatic equipment does the heavy work of lifting, turning and moving bulky engine blocks and other parts throughout the machining, assembling and testing operations. Relieved of tiresome manual operations, workers concern themselves largely with keeping the machinery functioning properly, checking quality of finished parts, and assembling engines.

C. H. Patterson, general manager of the Engine and Foundry Division, said, "The combination of highly trained employees and automated equipment in our plants enables us to offer the public the highest quality engines Ford has ever built. Automation, which is regarded as one of the most significant manufacturing developments of this generation, is a success only because of man's brains and skills. This latest Ford plant again proves that technological progress benefits the public by giving better products while simultaneously providing workers with better, safer and easier jobs."

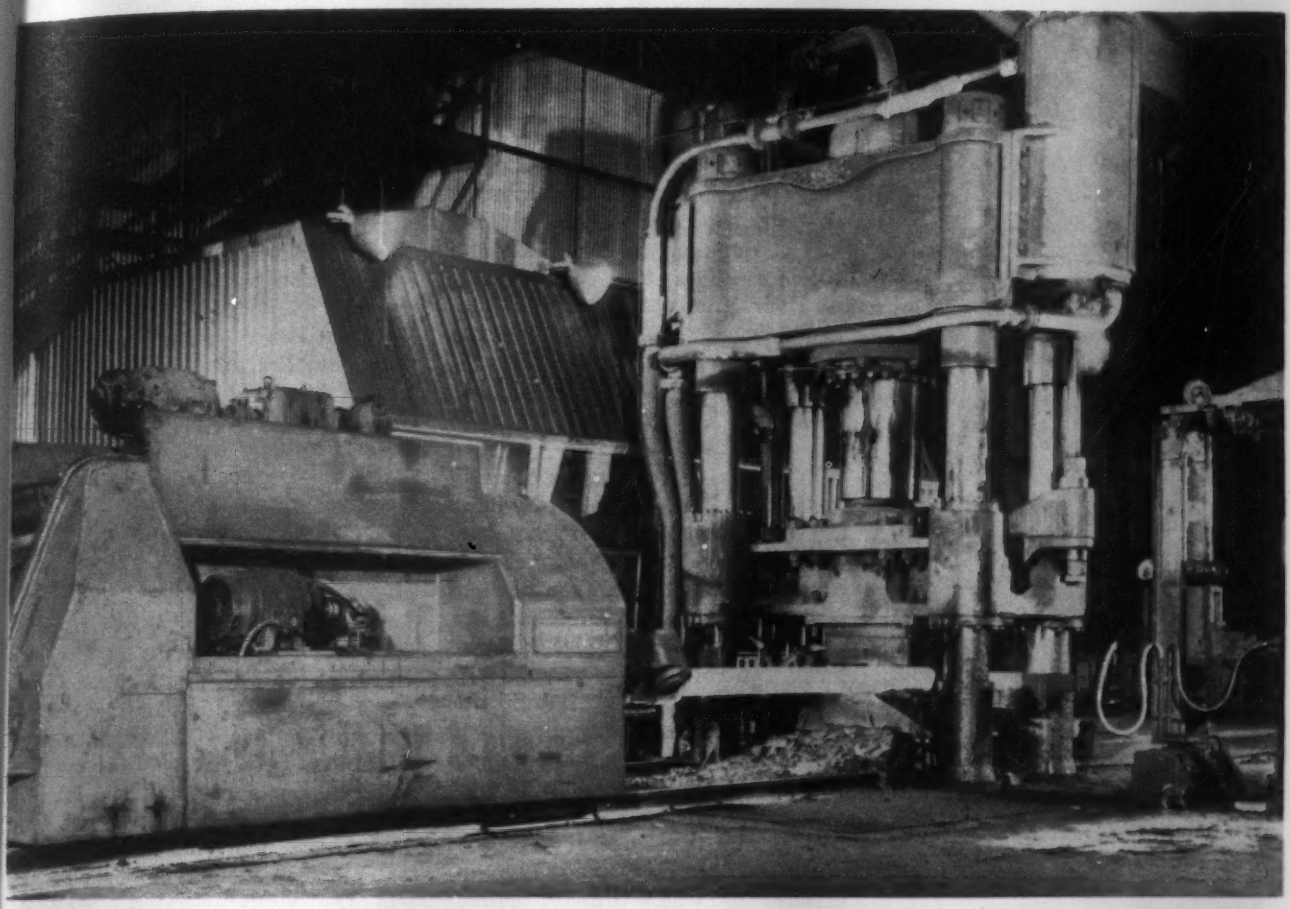
Electronic inspection devices in the new facility detect hidden imperfections and reject faulty parts; balancing machines spin such heavy items as crankshafts and direct cutting machines and other devices squeeze springs or tighten bolts to proper tension. One conveyor system stretches nearly two miles through the plant. It consists of overhead rails with suspended mechanical arms which carry engine blocks at convenient working height and in any position for easy placement of parts in assembly operation. When assembled, engines move automatically into a test area where water, gasoline and oil lines and electrical connections are attached. Each engine undergoes a test run of 20 minutes to insure proper operation before being shipped.



EVERY automotive engine built at Ford's new Dearborn Engine Plant is run under its own power in this testing department. Still attached to the mechanical arms which carry them through all assembly operations, the engines are routed automatically into these test stands. Here Ford technicians check engine timing and performance before approving the engines for shipment to assembly plants.

Servo Manufacturer Expands

PROGRAM of expansion was recently announced by Midwestern Geophysical Laboratory which in-



FOR PRECISE, remote control of a 5-ton forging manipulator at Cameron Iron Works Inc. both the manipulator and press operators are in an enclosure located next to the press. This provides excellent visibility and prevents physical abuse that would be encountered since the equipment is manned for the conventional eight-hour shift. The unit, designed by Kendall Engineering Co., uses a standard cone-drive vertical speed reducer manufactured by Cone-Drive Gears Div., Michigan Tool Co., to operate rotation of the manipulator. The reducer operates under Class III service—24-hour, shock loading conditions.

cludes a name change and corporate split as well as new plant facilities.

Parent organization will now be called Midwestern Instruments with the subsidiary organization retaining the former name and address of Midwestern Geophysical Laboratory, 3401 S. Harvard, Tulsa, Okla.

Midwestern Instruments concentrates most of its efforts in the field of hydraulic servomechanisms. It manufactures components such as torque motors, servovalves, servoamplifiers and actuators and also designs complete control systems.

New physical plant will contain 78,000 square feet of floor space and will be located on a 20-acre industrial site at 41st and Sheridan Rd., Tulsa, Okla. The expanded corporation is headed by **M. E. Morrow,** president; **G. R. Morrow,** vice president in charge of operations; **D. G. O'Brien,** vice president in charge of engineering; **A. E. McCoy,** vice president in charge of sales; and **E. J. Handley,** vice president.

Automation Story

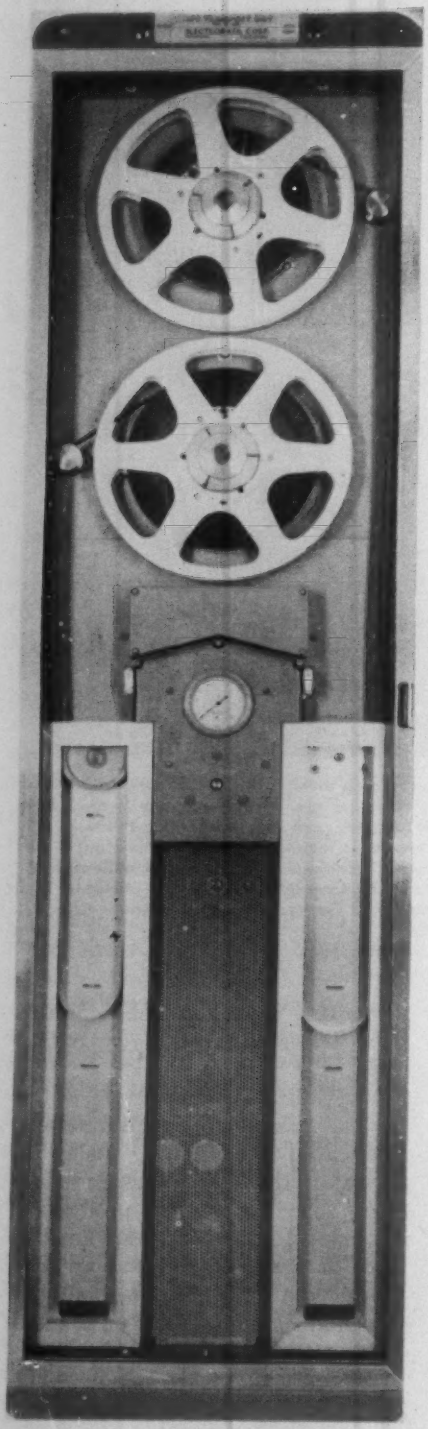
EXPLAINING automation in a humorous vein, a booklet, The Adventures of Countersunk J. Lathe, was recently introduced by Clark & Bobertz Inc. and has been distributed by several companies to explain and clarify the word "automation." The story says nothing about machine tools and mass production that has not been said before but its over simplified approach emphasizes the advantages of progressive automation.

Standardization Committee

LOOKING toward standardization of components in the field of automation, the engineering department of Radio-Electronics-Television Manufacturers Association has established an automation committee to combine and co-ordinate activities in this expanding area.

The staff-level committee is under chairmanship of **Walter Hausz,** of General Electric Co. Rising interest in the electronics industry regarding automatic production has made it apparent, a spokesman said, that a need for standardization exists that goes beyond the standing component and equipment committees of the Association.

In order to tackle the problem, subcommittees have been formed on terms and definitions, geometric or modular requirements, component requirements for automation, and automatic testing. Of these groups, the subcommittee on geometric and modular requirements is giving attention to the possibility of a set of preferred decimal numbers for the spacings between leads and the separation between



DESIGNED for use with most digital computers in data processing systems, new magnetic tape transport unit, manufactured by ElectroData Corp., has a capacity of 2400 feet of ½ or ¾-inch magnetic tape which is moved at optional speeds of 30, 40, 50, 60 or 75 inches per second by two constant-speed capstan motors. Provisions are made for installation of two recording-reading heads either of which can be selected remotely by mechanical control of the tape engagement.

terminals or holes in standardized grid fashion on printed circuit boards or other vehicles for electrical circuits. Subcommittee on component requirements for automation is designed to bring together the component manufacturers, the automation machine makers, and the equipment manufacturing companies, seeking compatibility of their interests through standardization.

Packaged Control Systems

CONTROLS for expansion of automation are being supplied by John C. Whiddett Co., previously specializing only locally in packaged control systems. Firm has now entered the national market as planner, designer and builder of automatic control units.

According to **J. C. Whiddett,** president of the company which has been solving industrial control problems for concerns located in the Delaware valley, "There are few, if any machines or processes where efficiency cannot be increased or where quality cannot be more closely controlled by design and installation of a packaged control system."

Each system is planned in conjunction with the purchaser's engineering department or plant superintendent. Systems may consist of a simple electrical device to control one machine or, in more complicated applications may combine electromechanical, pneumatic-hydraulic systems which require knowledge of what is available in standard off-the-shelf devices to cut costs and delivery time.

New Look for Soaking Pits

MODERNIZATION program which is expected to save its $90,000 cost within a year through quality improvements and production economies will be undertaken on a series of 28-year-old steel ingot soaking pits at Pueblo's Colorado Fuel & Iron Corp.

Company announced it had awarded a contract to Minneapolis-Honeywell Regulator Co.'s Industrial Division to engineer and install automatic control equipment for the old regenerative soaking pits. Controls will automatically regulate temperatures and pressures, and record and total flow of gas used to heat the pits.

Decision to install the control system was made after a nine-month experimental renovating project on one row of pits indicated definite savings in fuel costs in addition to increases in per-ton yield.

John R. Green, M-H steel industry manager, stressed the fact that automation of the steel-making operation was handled by off-the-shelf control equipment and did not require costly electronic controls or other components.

New Plant Facilities

LATEST development in the expansion program of Helipot Corp. is a Canadian plant located in Toronto, Ontario. The firm manufactures precision potentiometers and other components used in electronic and electromechanical systems, is a division of Beckman Instruments, Inc. and has four plants in the United States. **Roy A. Smart** is plant manager for the new Canadian plant.

Mathematical Simulation

RESEARCH scientists of Socony-Vacuum Oil Co. Inc. will soon put a high-speed electronic computer to work figuring out how to set the valves and fire the stills in an oil refinery to achieve peak efficiency.

Manufactured by ElectroData Corp., unit is now being installed at Socony's research and development laboratories at Paulsboro, N. J. To conduct the program, laboratory scientists have constructed a mathematical model of the Paulsboro refinery, using numbers and formulae to represent processing units. Model consists essentially of a group of about 100 equations which express mathematically the behavior of catalytic cracking, reforming, and other processing and blending units at the refinery. These equations are punched on cards, which are read by the computer and stored in the memory unit.

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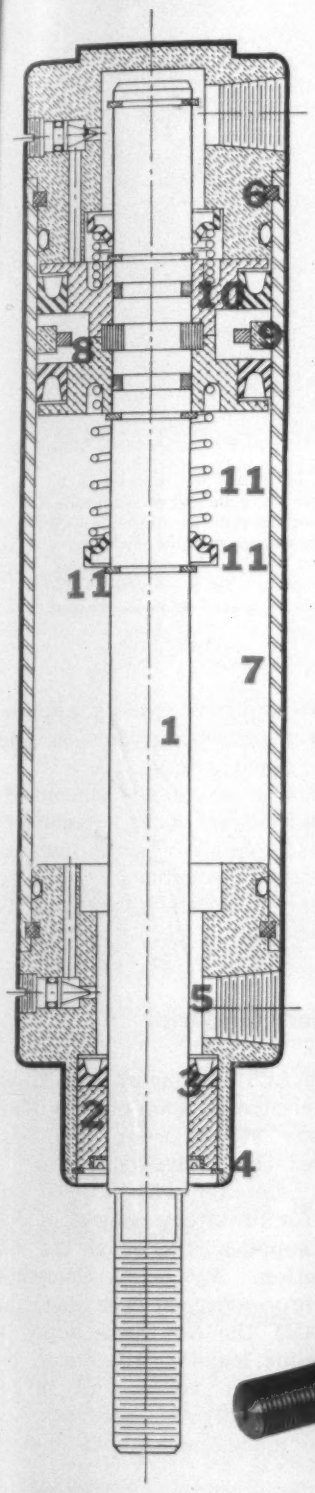

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ing data on crude oil characteristics, available charge stocks, motor gasoline specifications, product commitments, and other operating conditions and requirements will also be fed into the computer. Unit will then add, subtract, multiply, and divide these factors and come up with answers in as little as 15 minutes.

To do these computations with hand calculators would require 250 to 300 simultaneously operating hand units.

William M. Holaday, director of Socony-Vacuum laboratories stated, "We expect the computer to open many new avenues for petroleum research as well as new possibilities in the company's production, manufacturing, and distribution operations. In the field of production, we plan to use it to develop improved methods of recovering crude oil and natural gas from underground reservoirs. Among other areas in which it has potential uses are refining process development, catalyst research, reactor design, crude-oil analysis, and gasoline blending."

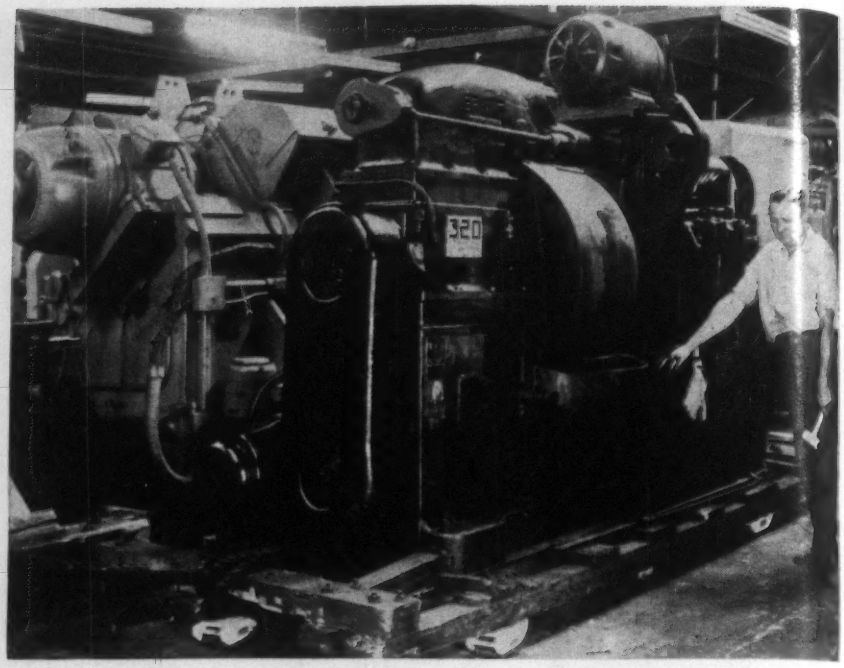
Expansion

COVERING 55,000 square feet, new Librascope plant in Glendale, Calif. is earthquake-proof and air conditioned. Firm manufactures analog and digital computers, components, and control systems and has a combined staff of over 1000 persons who now work in a total of 160,000 square feet of plant space.

Hydrogen Ion Control

NEW ELECTRONIC control, which will indicate the end of an operating run of a hydrogen cation exchanger (hydrogen zeolite) unit, has been developed by the Permutit Co. Device takes advantage of the fact that as the downflow hydrogen zeolite ion exchanger approaches exhaustion, the hydrogen concentration of the effluent has a higher conductivity than that of the upstream sample. Called the Enditrol, endpoints of the ion exchange run can be simply determined by comparing the conductivities of the upstream sample and the effluent.

Equipped with proper electrical controls, this device can also be used for automatically initiating the operation of existing automatic regeneration equipment. Operation of such units could be made entirely automatic and would eliminate dangers of overrunning and the chemical and water wastages caused by underrunning. The Enditrol may also be equipped with a relay so that it can signal the end of the operating run by an alarm bell or light arrangement.



TO HELP move heavy machinery, a self-laying track dolly, Multiton, developed by Stokvis-Edera & Co. Inc., utilizes roller skids based on the principle of an endless chain. Heavy steel rollers are joined by link courses around the centerpiece of the frame. Turntable has gripping teeth which imbed themselves in the wooden frame underneath load. When power is applied to load, units move forward, laying rollers ahead, as on a tractor or military tank. Since carrying heavy weights with device is a "unit method", the skids can be placed wherever needed in relation to center of gravity.

Group Engineering Services

ORGANIZATION of an integrated engineering group to provide a complete engineering service for design, construction and installation of industrial recording and control systems is announced by Berkeley division of Beckman Instruments, Inc.

Headed by **Wallace E. Rianda,** group represents engineering talent drawn from the organization's research and development, applications engineering, production, and service departments.

Groups service includes consulting engineering, design, construction, supervision of field installations and preparation of operating and service manuals for complete systems.

Inventory Computer

CONTRACT to install an ELECOM electronic computer at Mallory Air Force Depot, has been awarded the Underwood Corp.

The computer will be used initially for inventory control of Air Force supplies stocked at the AF installation. By using electronic data processing devices such as ELECOM, the Air Force hopes to streamline logistic procedures, reduce pipeline times and inventories, and provide accurate and timely management and budget data.

System to be installed consists of an electronic digital computer with an internal memory capacity of 2000 words and a rapid access memory unit of 50 words; three

typewriter units for information input and output; eight magnetic tape units for external storage; punched tape reader (Ferranti) to operate at the rate of 400 characters per second; punched card input-output facilities and a separate sorting unit. Machine will handle addition and subtraction, multiplication and division problems. Data is read or recorded by ELECOM at the rate of 2000 digits per second.

Manager Appointed

APPOINTED manager of the newly expanded industrial division of the North Electric Mfg. Co. **Raymond W. Ayers** will be in charge of sales and applications engineering for airborne and industrial type relays, automatic control systems, industrial and railroad carrier, automatic internal communications equipment and computer and other automatic system components.

Mr. Ayers came to North from the Allen D. Cardwell Co. electronic component manufacturers, where he was executive vice president, and brings to his new post a broad background of experience on electronic manufacture and sales. He is a graduate of the University of Illinois.

Electronics Field Newcomer

FORMATION of an electronics engineering and manufacturing organization, Ransom Research, was announced recently by **David H. Ransom,** founder of the company.

New company is currently manufacturing electronic decade counters and electronic voltage regulators. New products are being de-

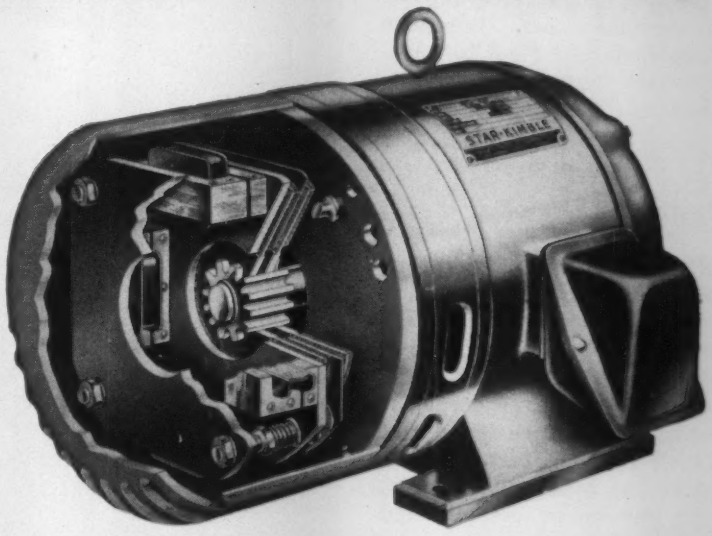
STOP! START STOP! START STOP! START STOP!

START STOP! START STOP! START STOP! START

START STOP! START STOP! START STOP! START

Instantaneous Drag-free

STOPS! STARTS



STOP! START STOP! START STOP! START STOP!

minute after minute YEAR AFTER YEAR
with Star-Kimble Brakemotors

That extra-large brakelining area you see brings a Star-Kimble Brakemotor and its connected load to an *extra-fast stop*—as short as a fifth of a second from full speed to standstill if desired.

And the small air gap contributes to *equally fast starts*. Brake is released the instant motor current is switched on—equipment starts without drag.

That's the story of a *single* Star-Kimble stop-start cycle. And the experience of user after user *proves* that Star-Kimble Brakemotors *maintain* the same split-second stops, the same smooth starts, through hundreds of thousands of cycles. In reversing service, conventional plugging methods with a typical 5 hp motor allow only 3 starts per minute. With a Star-Kimble Brakemotor, the figure is boosted to 10!

Of course, every Star-Kimble Brakemotor is a compact, integral unit designed to save space—and give rugged, dependable performance. One manufacturer—one responsibility.

For the full story, write for Bulletin B-501-A

STAR-KIMBLE
MOTOR DIVISION
MIEHLE PRINTING PRESS AND MFG. CO.
222 Bloomfield Avenue Bloomfield, New Jersey

veloped for industrial automation, electronic computer and railroad communications applications.

Mr. Ransom, an electronic scientist, has made notable achievements in the development of magnetic amplifiers, microwave radio relay systems and telephone switching systems. Prior to forming the new firm, Ransom was president of Mag-Electric Products.

Multipurpose Thermocouple

DEVELOPMENT of a new type thermocouple, used for measuring temperature changes, has been announced by the Engineering Division of Midwest Research Institute.

Featuring quick response for measuring temperature changes of metal wall surfaces, instrument is applicable for recording temperatures in gun bores, cylinder and piston walls, brake drums, aircraft skins, autoclave walls, and air ducts. This special thermocouple has been specifically designed to operate effectively under adverse conditions, and has been satisfactorily tested at pressures up to 60,000 psi under severe mechanical vibration.

Circuit Printers

FORMED to design and manufacture various types of printed circuit boards, Printed Circuits Inc. announced recently that the company's production facilities are now in operation.

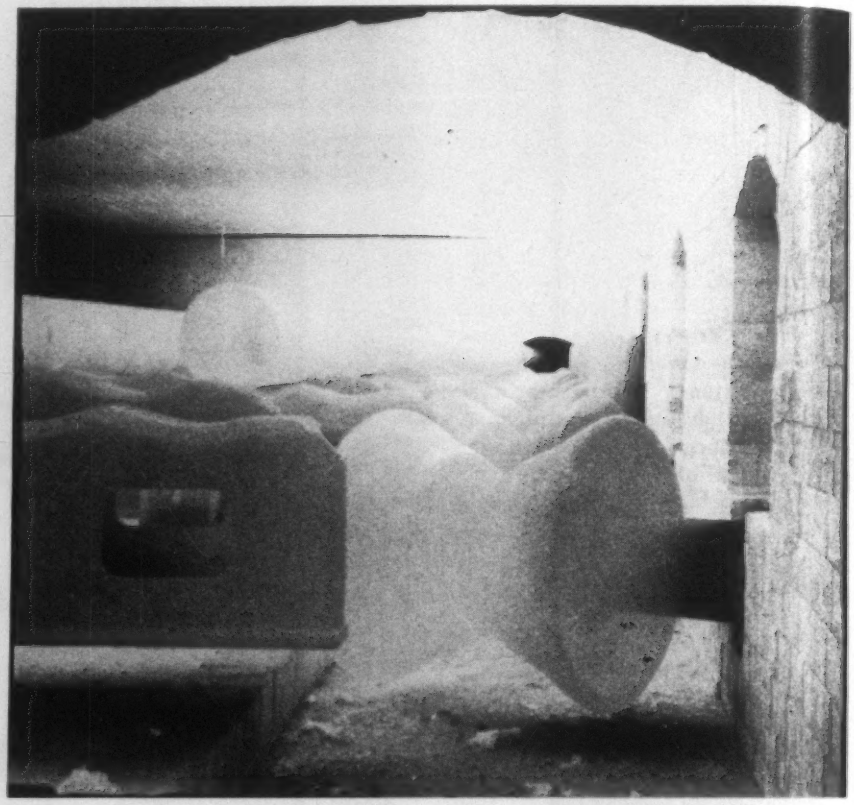
Chauncey T. Mitchell, who has a broad background in the conversion of conventionally wired chassis and the production of printed circuits, is serving as general manager of production and engineering. **Ernest E. Carpenter** heads the new firm.

Size Increase for Rectifiers

TO GAIN wider acceptance for high temperature rectifiers among industrial manufacturers, Semi-Conductor Division of Radio Receptor Co. has succeeded in reducing costs and increasing cell sizes to 5 by 6 inches on these units which operate without derating at 125C.

Introduced by Radio Receptor less than three years ago in sizes limited to 3 by 3 inch, high temperature rectifiers have until now been almost prohibitive even for military uses, because of high price and size limitations.

The picture has now improved considerably as availability of larger sizes means engineers can have nearly unlimited selection. Reduced price qualifies new rectifiers for a wider range of military applications and industrial uses.



PIPE being carried through 1650F furnace by York-Gillespie equipment moves through slowly from left to right on the conveyorized furnace bottom, passing out of the exit door in the background. Skewed rollers rotate the pipe axially and also move it longitudinally out of the furnace.

Conveying Tubular Products

SPECIAL MATERIALS handling equipment recently developed for transferring tubular steel products through a continuous normalizing and annealing furnace is expected to increase steel mill output of high-strength steel products in addition to increasing savings in strategic alloying materials such as manganese, molybdenum and chromium. Equipment was designed and built by York-Gillespie Mfg. Co.

First installation of this furnace equipment has been put in successful operation in the new heat treating line at Jones & Laughlin Steel Corp.'s Aliquippa Works, for processing high-strength oil well pipe.

New equipment incorporates a design feature which permits a tubular product to be rotated as it moves through the furnace. A fully-sealed hearth in a conventional furnace assures uniformly controlled heat and prevents chill spots from developing.

Skewed rollers rotate the pipe as it enters the hot zone of the furnace, minimizing warpage. Specially-designed walking beam racks in the furnace proper keep pipe properly spaced and rotate it as it is transferred. A kickoff mechanism is electrically controlled and timed to remove the pipe from the furnace entry table and to deposit it on the furnace racks.

System can also be used for solid rounds. At J & L, the equipment

permits a range of product sizes from 2⅜ to 10¾-inch diameter, with no modification of the equipment required to process the various sizes. A maximum weight of 60,000 lb per hour is carried through the furnace at 1650F.

Automation Sales Manager

APPOINTMENT of **Ralph B. Billingham, Jr.** as sales manager of the automation section was recently announced by W. F. & John Barnes Co. Mr. Billingham joined the company in 1947 as a design engineer for automation equipment, was promoted to sales engineer, and more recently, was assistant sales manager of the section that he now heads.

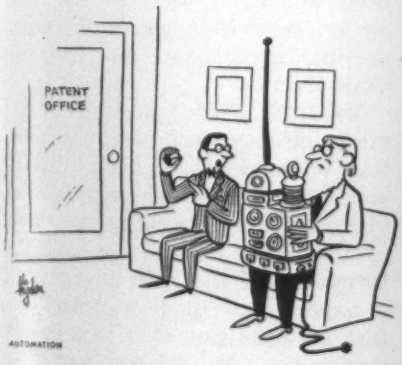
Automation section is engaged in the design and manufacture of a wide range of automatic equipment including specialized conveyor units and systems for solving materials handling problems. Metalworking, automotive, farm implement, food, drug, wood, and paint industries are served.

Quick-Opening Cover

HYDRAULICALLY operated, quick-opening cover is a new operational and safety feature on horizontal and vertical filters manufactured by Niagara Filters Div. of American Machine and Metals Inc.

Features include: quick effortless opening and closing of the filter tank, even seating of the cover and reduced maintenance costs.

Actuation of the hydraulic pump transmits pressure to a pair of hy-



"That's odd . . . I've got a little device right here that does the same job automatically!"

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AUTOMATIC TIMING

WILL
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- REDUCE REJECTS
- INCREASE PRODUCTION

If you manufacture a product, quality timing or counting will control your processes with less wasted time . . . with increased precision . . . and will speed up production. The element of human error, increased with fatigue, often is responsible for trouble-making rejects. Eagle engineers will build a timer to answer your production problems. Send your problem today.

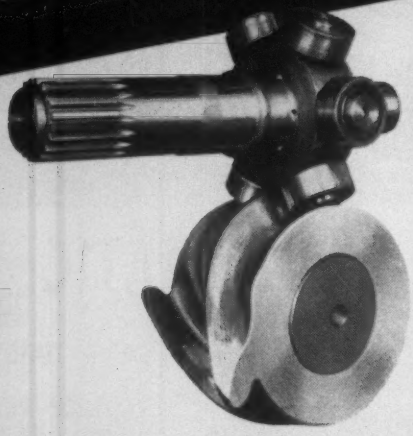
Write for FREE AUTOMATION BOOKLET "See What Timing Can Do For You"

Industrial Timers by EAGLE

EAGLE SIGNAL CORPORATION MOLINE, ILL.

Eagle Timers save time, save money.

HIGH SPEED INDEXING



The FERGUSON DRIVE...

ELIMINATES SPEED LIMITATIONS IN YOUR PRODUCTION MACHINERY

★ *Up to 1000 Indexes Per Minute*

★ *Increase Production 100%*

★ *Up to 20,000 Hours with No Maintenance*

GENEVA DRIVES LIMIT PRODUCTION!

Modern production methods require speeds and precision impossible to obtain with geneva drives and other obsolete indexing devices. The Ferguson Roller Gear Drive makes it possible to increase production speeds as much as 100%, *while improving product quality and reducing maintenance costs!* The Ferguson Drive, the greatest development in indexing in the last thirty years, attains indexing speeds up to 1,000 per minute in some applications without undue shock or vibration to the Drive or machine. If you have machinery utilizing dial feeds, roll feeds, carrier chains and other types of intermittent feeding methods, investigate the Ferguson Drive and discover what it can do for you.

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SEE THE **ROLLER GEAR** at the ASTE SHOW
Booth #973 • Mar. 14-18
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Manufacturers of the Ferguson Trans-o-Mator, Ferguson Roller Gear Drives, Dial Feed Index Tables, Roll Feeds for Presses, Special Cams, Special Purpose Machinery.

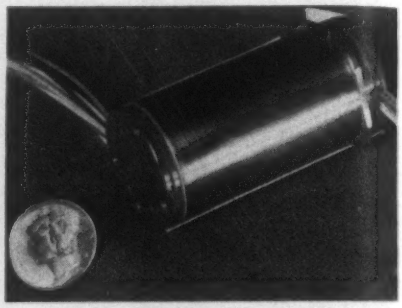
ferguson

FERGUSON MACHINE & TOOL CO., INC.

ROLLER GEAR DIVISION, DEPT. AI-2 P. O. BOX 191, ST. LOUIS 21, MO.

draulic cylinders which in turn rotate the locking ring. Resultant cover pressure against a gasket ring seals filter securely. Reversing the motion of the locking ring releases cover so that it can be removed. This type of closure provides a safety feature in that the cover cannot be opened until wedges on the locking ring and cover clear each other. Pressure is automatically released at the first movement of wedges.

Because of uniform pressure exerted by the hydraulic system, as compared with the "spot" pressure exerted by hand wheels and eye bolts, even seating of cover against gasket is assured. Repair and replacement of hand wheels and eye bolts is also avoided.



NEW GYRO produced by Greenleaf Mfg. Co. is believed to be one of the smallest hermetically sealed integrating gyros in use today. Complete unit is an inch in diameter by a little more than 2 inches long and is an outgrowth of research done by the USAF at the instrumentation laboratories of MIT. Fire control systems and missile manufacturers can benefit from space and weight savings realized

Manager—Automation Dept.

SENIOR FIELD engineer in the mechanical engineering department, **Mr. E. K. Sutherland,** has been appointed manager of the newly created automation engineering department at Corning Glass Works.

Mr. A. W. Weber, director of engineering explained that automation is gaining increasing use in modern industry. A number of glassmaking processes are now controlled by automation and the formation of the new department is expected to apply increased effort to development of automatic machinery. Mr. Weber said that many of the new products sold by Corning Glass Works require a

high degree of automation in order to achieve the quality required.

Mr. Sutherland has been associated with the company since 1945 when he joined the mechanical engineering department as a research technician. A year later he was appointed an engineer in machine design and in 1951 was named a senior field engineer specializing in television bulb machinery.

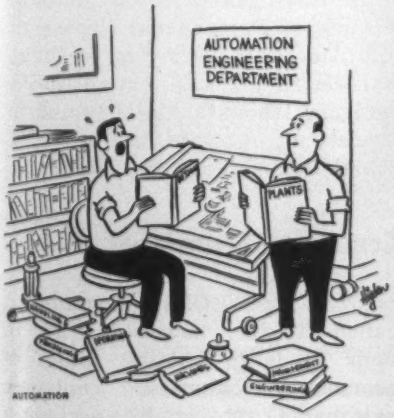
Special Projects Solved

CONSULTING and research chemists, Crippen & Erlich Laboratories Inc., have developed a novel approach to undertake special projects in organic chemical fields. They develop methods for synthesis of a compound, methods for its analysis and control in manufacturing and use, convert this data to a pilot plant and obtain further data for large scale manufacturing. Firm also determines uses for organic chemicals and conducts market surveys.

V.P. Appointed

ELECTION of **Carl W. Petersen** as vice president and works manager of Dodge Mfg. Corp. was announced recently by **Joseph E. Otis, Jr.**, president.

This announcement is coincidental with the retirement, under the regular Dodge retirement plan, of **Edgar M. Carver** as first vice president of Dodge, a Mishawaka, Ind. manufacturer of power transmission machinery. He will continue to serve as a member of the



"Remember the good old days, when all you had to know was how to draw?"

Ferguson STANDARD INDEX TABLES FOR HIGH SPEED PRODUCTION

The Ferguson INTERMITTOR offers

★ *Over 150 Standard Models*
★ *Ease of Installation and Tooling*
★ *30,000 Precision Pieces Per Hour*
★ *Lower Maintenance Requirements*

Cut production costs with the new FERGUSON Intermittor, the standard index table that features *high speeds* with *smoothness* of operation; extreme *precision* with no shock-causing auxiliary locking or locating mechanisms; up to 20,000 hours operation with *no maintenance* and complete drive renewal merely by replacing inexpensive ball bearings.

The Intermittor gives you complete choice of profitable work time with a minimum of "wasted" rest during the cycle because movement time may vary from 25% to 75% of the total cycle time. You get more pieces per hour . . . at less cost per piece.

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Manufacturers of the Ferguson Trans-o-Mator, Ferguson Roller Gear Drives, Dial Feed Index Tables, Roll Feeds for Presses, Special Cams, Special Purpose Machinery.

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FERGUSON MACHINE & TOOL CO., INC.

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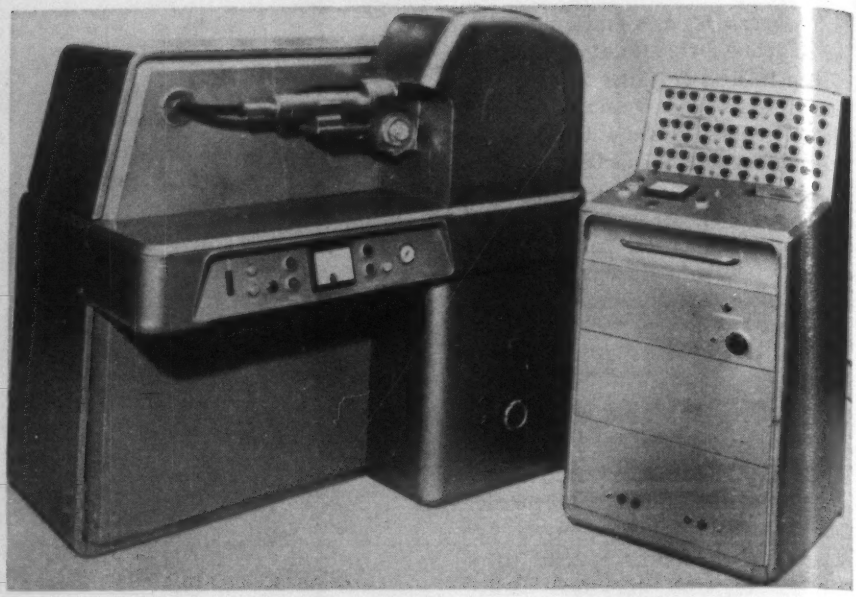
board of directors and has been appointed to act as a consultant to the corporation. Mr. Carver has been associated with Dodge for over 45 years.

Mr. Petersen moves forward from the position of general superintendent after serving in that capacity since 1942. His career with Dodge started in the summer of 1923 when he was a student in Iowa State College. That fall he was elected to Tau Beta Pi, and the following June was graduated from Iowa State with a B.S. degree in mechanical engineering. Mr. Petersen then returned to Dodge. A succession of promotions brought him to the position of assistant superintendent in 1939 and to his appointment as general superintendent three years later.



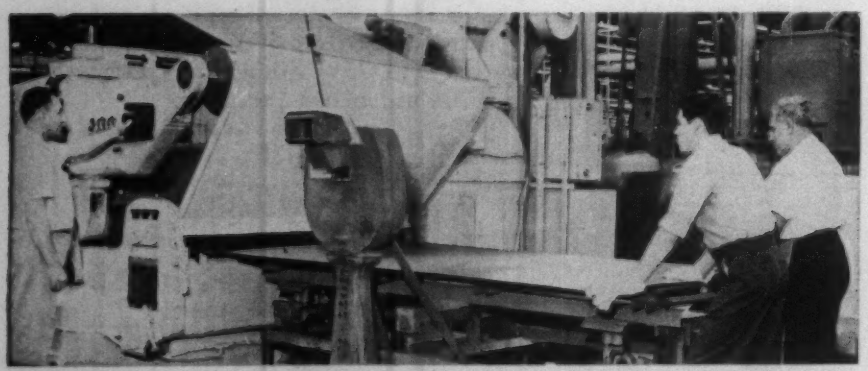
AUTOMATIC multielement indexing X-ray spectrograph, Autrometer, gives percentages of as many as 12 elements in a specimen. The instrument is capable of measuring 71 elements in the periodic table. Developed by the Research and Control Instruments Division, North American Philips Co. Inc., the machine is radiation proof and provides accurate and rapid analysis of products in any critical stage of manufacture. New unit indicates need for the addition or removal of elements which will guarantee uniformity of mixes, batches or correct degree of purity for components. Designed to save time and effort for the chemist and production and quality control engineer, Autrometer will be of value for precise quality control of materials from the incoming (raw) state through processing to the finished product.

Double Feature For Automation

TWO SHOWS—the Machine Tool Show and a new Production Engineering Show will be held concurrently in Chicago—Sept. 1955. Clapp & Poliak, Inc. exposition management firm, announced that the shows will take place from September 6 to 17 inclusive. The Production Engineering Show will be held at Navy Pier and the Machine Tool Show at the International Amphitheatre.

Production Engineering Show will cover the field of automation and will be held annually. Automatic mechanisms and techniques for manufacturing and processing industries will be demonstrated. Combined events are expected to attract 200,000 individuals from all over the world. Railroads, steamships and airlines will schedule special runs.

Partial category list of equipment to be exhibited at the new automation show includes: monitoring equipment, counters and computers, communication equipment, materials handling equipment, inspection and gaging devices, industrial television, radio, teleprinter, etc. Components, such as cylinders, brakes, clutches, drive mechanisms and motors, will also be exhibited.



AUTOMATIC equipment which shuttles steel sheets back and forth through this grinder has brought a 50 per cent production increase on this machine at Hamilton Standard, division of United Aircraft Corp. Steel sheets, used in manufacture of hollow steel propeller blades, are fed into machine while operator sets counter to required number of passes.

PE Becomes VP

PROMOTION of **Norman Lieblich** to the post of vice president of Kieley & Mueller, Inc. was announced recently. Lieblich was general sales manager and previously had served with the firm, which manufactures control valves and steam specialties, as chief applications engineer.

He is a member of the National Society of Professional Engineers, the American Society of Mechanical Engineers, the American Petroleum Institute, the Instrument Society of America, and the National Steam Specialty Club.

Controlling Flour Level

NEW ELECTRONIC instrument, called Tektor, controls level of flour in large holding tanks of commercial bakeries. Replacing antiquated dip stick and sight glass level control method, Tektor, developed by Fielden Instrument

Div. Robertshaw - Fulton Control Co., controls levels with accuracy of plus or minus one per cent.

Awrey Bakeries in Detroit is using this instrument to control the level of flour in a large holding tank. The light and nonconductive nature of flour makes use of other types of level control equipment unsatisfactory.

Device is actuated electronically using a simple plastic covered sensing probe extended into the tank. When the air surrounding the probe is displaced by material of higher dielectric character, a signal is given at the instrument and level control initiated.

Evolution Not Revolution

PREDICTED change in the value ratio of plant equipment to land and buildings from 2:1 to 4:1 in the next decade will be largely a result of the increasing emphasis on the automation of production processes, according to **Dr. L. T. Rader,** general manager of General Electric Co.'s specialty control department.

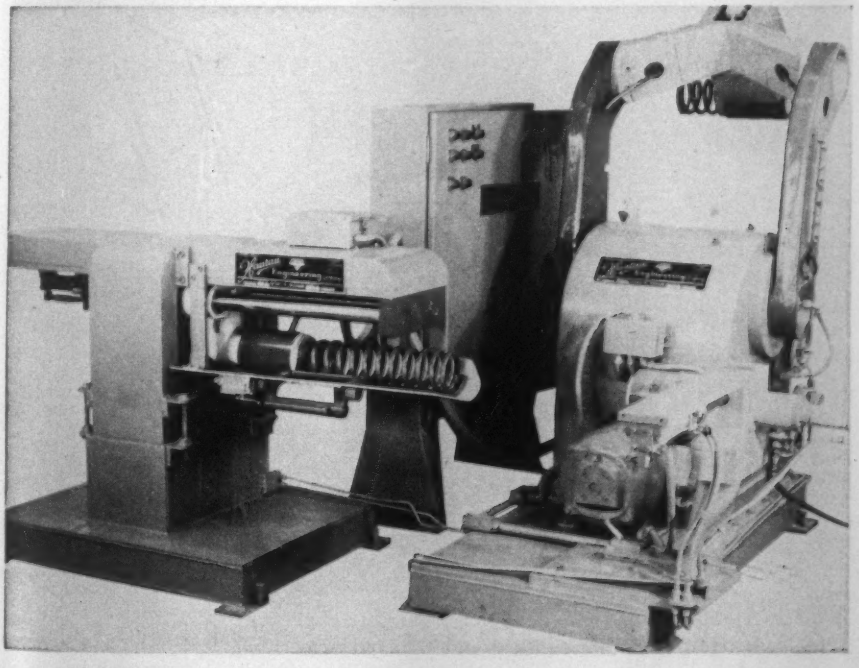
In a recent speech, Dr. Rader pointed out that the dynamic nature of our future economic climate together with an increased willingness to solve problems by technology are important factors in this prediction.

"This, however, does not mean that industry's progress towards automation will be revolutionary, that tomorrow the countryside will be dotted with automatic factories. The cold facts of economics will continue to govern the growth of automatic controls in industry, and their successful adoption requires such detailed study, followed by periods of trial operation, that progress will continue to be evolutionary, rather than revolutionary," he stated.

New District Office

TO PROVIDE centralized sales and service facilities for instrument users in New York state, the northwestern section of Pennsylvania and the Canadian provinces of Ontario and Quebec, Consolidated Engineering Corp. has announced the establishment of a Buffalo District Office.

New facility headed by **Eugene J. Moscaret,** resident field engineer, will operate under the jurisdiction



LOADER which receives hot automobile springs from a coiler, rotates them into an oriented position and transfers them to a quench bath is now available to industry. This machine, which is the latest of a line of automation loaders designed and built by Hautau Engineering Co., will handle up to 700 springs an hour. Springs are coiled at red heat and must be transferred from the coiler to the quench bath in minimum time to insure proper heat treatment. New unit accomplishes both transfer and orientation in five seconds, automatically controlled and cycled so that it may be used in timed sequences with other production machinery.

TRANSISTOR &

DIGITAL COMPUTER

TECHNIQUES

applied to the design, development and application of

AUTOMATIC RADAR DATA PROCESSING, TRANSMISSION AND CORRELATION IN LARGE GROUND NETWORKS

ENGINEERS & PHYSICISTS

Digital computers similar to the successful Hughes airborne fire control computers are being applied by the Ground Systems Department to the information processing and computing functions of large ground radar weapons control systems.

The application of digital and transistor techniques to the problems of large ground radar networks has created new positions at all levels in the Ground Systems Department. Engineers and physicists with experience in the fields listed, or with exceptional ability, are invited to consider joining us.

fields include

TRANSISTOR CIRCUITS
DIGITAL COMPUTING NETS
MAGNETIC DRUM AND CORE MEMORY
LOGICAL DESIGN
PROGRAMMING

VERY HIGH POWER MODULATORS AND TRANSMITTERS

INPUT AND OUTPUT DEVICES
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Scientific and Engineering Staff

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RESEARCH AND DEVELOPMENT LABORATORIES

Culver City, Los Angeles County, California

Relocation of applicant must not cause disruption of an urgent military project.

• DOES
OUR PRODUCT LINE
LEND ITSELF TO
AUTOMATION?

• WHAT
WILL IT COST?

• WHAT
RETURN WILL I GET?

• HOW
SHOULD I DO IT?

This is the type of questions we are called upon to answer for our clients. Let our company answer these questions for your plant. Write today.

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ROLL and WRAP
FLEXIBLE MATERIALS
automatically

You can save time and labor with a Dyken machine if you roll lengths of
SCREENING • LAMINATED PAPER
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• WALLPAPER • CARPETING •
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and other pliable materials!

ONLY A DYKEN Rolling Machine will roll (or roll and paper-wrap) lengths of flexible material . . . *without requiring center cores, starting bars or mandrels.* Automatic starting. Push-button control permits using unskilled operators. Compact rolls save storage and shipping space. Standard machine models available for all material widths and lengths. Fully patented.

WRITE TODAY FOR COMPLETE DETAILS—Describe your problem fully for recommendations by our engineers. No obligation.

DYKEN MFG. CO., Inc.
742 Indiana Ave.
West Bend, Wis.

of the Eastern Regional Office in Philadelphia. Mr. Moscaret has served as an application engineer and specialist in high vacuum leak detection technology. He was graduated from the University of Rochester with a degree in physics in 1948. Prior to his present association, Moscaret was an engineering supervisor in the AEC Project Division of the American Locomotive Co., and from 1948 until 1949 was a research engineer on radar projects for Airborne Instruments Laboratory. He is a member of the American Physical Society and the Instrument Society of America.

Executive Director ISA

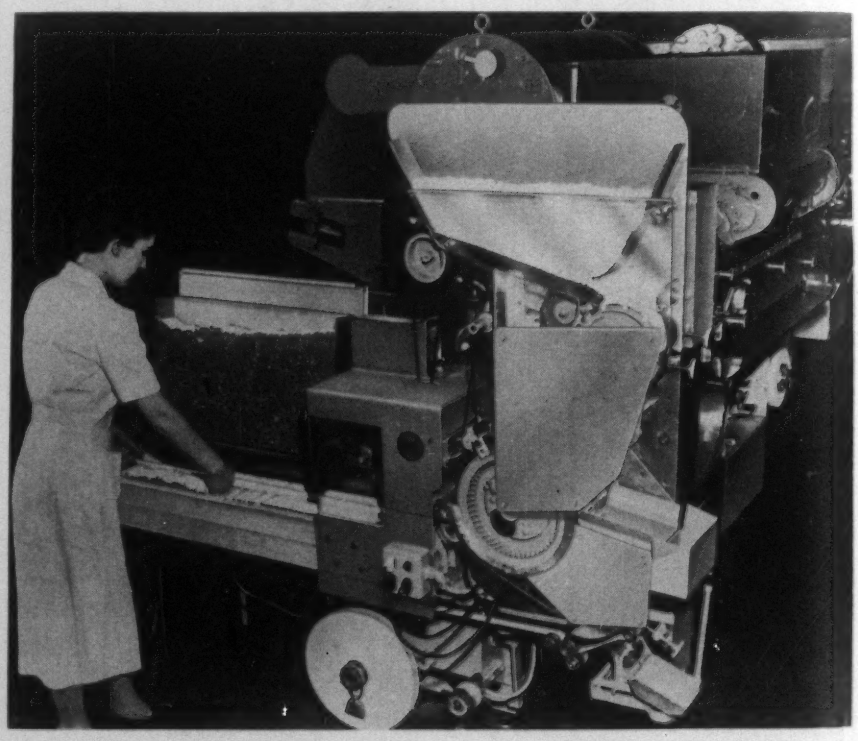
FORMERLY Director of the School of Management, American Management Association, **William H. Kushnick** has been appointed executive director of the Instrument Society of America. He is a graduate of the School of Industrial Engineering, New York University, and prior to 1941, he was employed as a production executive for several companies which merged to form the Anchor-Hocking Glass Corp.

During World War II, Mr. Kushnick served as director of civilian personnel and training in the Office of the Secretary of War. Before becoming associated with the American Management Association, he worked as a management consultant, both in private practice and on the staffs of other management organizations.

Dew Point Control

HUMIDIFICATION system which controls the dew point of combustion air has slowed the formation rate of fireside deposits on boiler tubes of stoker-fired furnaces at the Detroit Edison Co. The system is controlled by a Foxboro Dynalog Stabilog Controller and has substantially reduced the number of shutdowns for cleaning and repair.

Moisture content of air from preheaters is measured by a Foxboro Dewcel element which senses the dew point of a continuous sam-



MECHANISM which can be attached to any cigarette-making machine to add filter-tips can turn out tipped cigarettes as fast as cigarettes are produced. Attachment developed by American Machine and Foundry Co. accepts two cigarette lengths simultaneously from the cigarette-making machine, inserts a double-length filter plug between them, wraps the assembly with tipping material and cuts through the center of tipped section to form two filter-tipped cigarettes. Unit becomes an integral part of cigarette manufacture, differing from many existing filter-tipping methods which require separate machines for the process.

ple of air piped to a sampling chamber. The controller receives this dew point measurement, records it on a circular chart and automatically operates a valve to control flow in the water admission line. Water enters the air ducts in the form of a fine mist sprayed through steam atomizing nozzles. In this manner, moisture content of combustion air is maintained at 79F dew point, proved by tests to produce an optimum low rate of fireside deposit formation.

MEETINGS AND EVENTS

Feb. 10-12—

Institute of Radio Engineers. Seventh annual Southwestern IRE conference to be held Baker Hotel, Dallas, Texas. Additional information may be obtained from T. W. Sharpe, 1930 Hi-Line Drive, Dallas 2.

Feb. 17-18—

AMA Manufacturing Seminar. Second of two meetings to be held AMA headquarters, New York, on practical application of automation. Additional information may be obtained from association offices, 330 W. 42nd St., New York 36.

Feb. 23—

Instrument Society of America. Annual winter conference to be held Hotel Statler, New York. Additional information may be obtained from Hamilton Bristol, general chairman, 250 W. 57th St., New York.

Mar. 1-3—

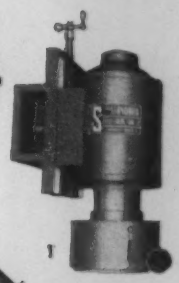
Western Joint Computer Conference. Exhibition and conference to be held Hotel Statler, Los Angeles. Additional information may be obtained from William Gunning, 2000 Stoner Ave., Los Angeles 25.

Mar. 1-3—

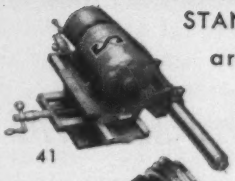
Society of Automotive Engineers. Golden anniversary passenger car, body, and materials meeting to be held Sheraton-Cadillac Hotel, Detroit, Mich. Additional information may be obtained from society headquarters, 29 West 39th St., New York 18.

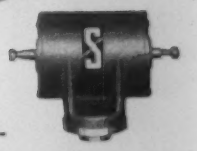
STANDARD has a spindle for every purpose!

PRECISION MOTOR-DRIVEN SPINDLES OR WORK HEADS



STANDARD spindle users are a "Who's Who" of American metal working . . . here's the perfect answer to modernizing old machines . . . developing special combinations with regular spindles.





PRECISION BELT-DRIVEN SPINDLES

★ DYNAMICALLY BALANCED
★ PRECISION ENGINEERED
★ EXTRA HEAVY DUTY

SPECIAL PROBLEMS?

Tell us about them . . . WE'LL DESIGN A SPINDLE FOR YOU . . . we take great pride in our reputation for custom engineering in the spindle field.

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Since 1912

the STANDARD electrical tool co.

PRECISION SPINDLES AND MACHINE TOOLS

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MR. DESIGNER:

A Standard Spindle in that special machine means

DAY-AFTER-DAY, TROUBLE-FREE PRODUCTION

Drop us a line today and we'll send you the story. You'll see why more and more production people are making it a rule to

SPECIFY STANDARD SPINDLES!

BLISS' 1000th Transfer Feed Press

*It feeds itself \ checks and corrects errors \ performs 11 separate press operations \ and delivers 28 completed parts per minute *

all automatically

At Ford Motor Company's Ypsilanti plant, the Bliss 13-station transfer feed press turns out starter brush end plates—a part which was formerly die cast.

The press takes the 0.090-inch blank, puts it through six successive draws, flanges it, irons the cup within a tolerance of ±0.0005" on the I.D., restrikes the flange, pierces ten tiny holes, lances four locating tabs, and then trims the part to final diameter. Tolerance range throughout: from ±0.0005" to ±0.005".

And while all this is going on all the attendant has to do is keep the turret mechanism loaded with blanks!

However, the truly unusual feature of the press is this: practically everything that can go wrong has been anticipated and guarded against by electrical control circuits. Tiny switches police trouble areas and take corrective measures when needed.

In short, the press thinks as it works—*that's* automation. An up-to-the-moment example of Bliss press engineering, this transfer feed press is the thousandth such press produced by Bliss since it pioneered the transfer feed principle back in the 90's. Today Bliss transfer feed presses are a by-word in arsenals, can-making and metalworking plants—wherever speed and accuracy are musts.

If you have a pressroom problem—large or small—a Bliss field engineer will be glad to help you in whatever way he can. And behind him stands the resources of the entire Bliss organization—the world's largest press builder.

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Real Advance

Not entirely alone in basic philosophy, AUTOMATION is firmly convinced that out of the rise of automatic operations in general will come great advances. Among these will be a significant improvement in the personal well-being of working people aside from merely higher standards of living.

Some have hailed automation as leading to elimination of unskilled workers and eventually the semiskilled with the attendant problem of unemployment. Others have predicted the further reduction in man's significance, loss of personal relation to work and the "feel" of it. And finally there are the prophets of doom who find that no more workers will be needed and that not only the worker but also work itself will be displaced by the machine with ominous results.

Research into the true character of the development reveals a somewhat different picture. First, as a slow evolutionary movement primarily guided by economics, engineering development and market conditions, automation will create no revolution. Second, any genuine accomplishment in this field entails a tremendous work load for accomplishment—complex automation installations require long years of intense work to reach fruition with a fabulous investment in real work. Third, while such plants require much less direct labor, maintenance of continuous operation with improved and expanded output offers little in the way of reduced overall work. Fourth, any imaginary personal relation to the product produced by the so-called contact with it is supplanted by the very real feeling of personal worth created by the requirement of know-how to insure successful operation. Actually, the unskilled machine operator of yesterday is being trained by industry to take his place in the new class of workers—skilled technicians. Fifth, to think that the vastly more complex automation going into service today will displace work itself is something bordering on the ridiculous.

No, there need be no fear that such conditions could come to pass. As the slow transition takes place the increased concentration and co-ordination of highly skilled, engineering and scientific work necessary will continue to absorb all the brain power that can be brought to bear. Overall satisfaction will be greater, consumption will increase, true enjoyment of life will be more widely attainable, and instead of merely doing any job for a living, men will be living to do a job.

H. A. Bolz

EDITOR

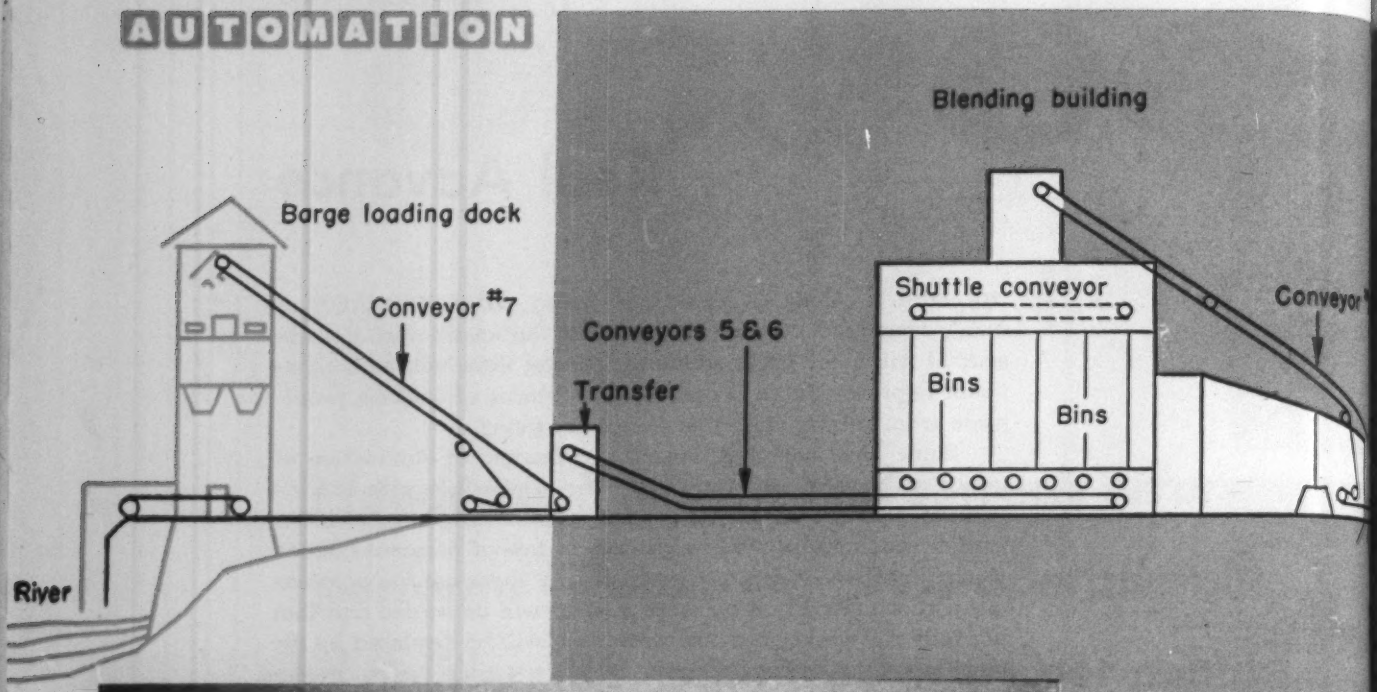

Fig. 2—Rotary car dumpers at Chesapeake and Ohio Railway Pier 14, Newport News, Va.; part of a coal handling system for loading ocean-going ships

Fig. 3—Conveyors lead from the hoppers of *Fig.* 2 to the loading towers on the pier

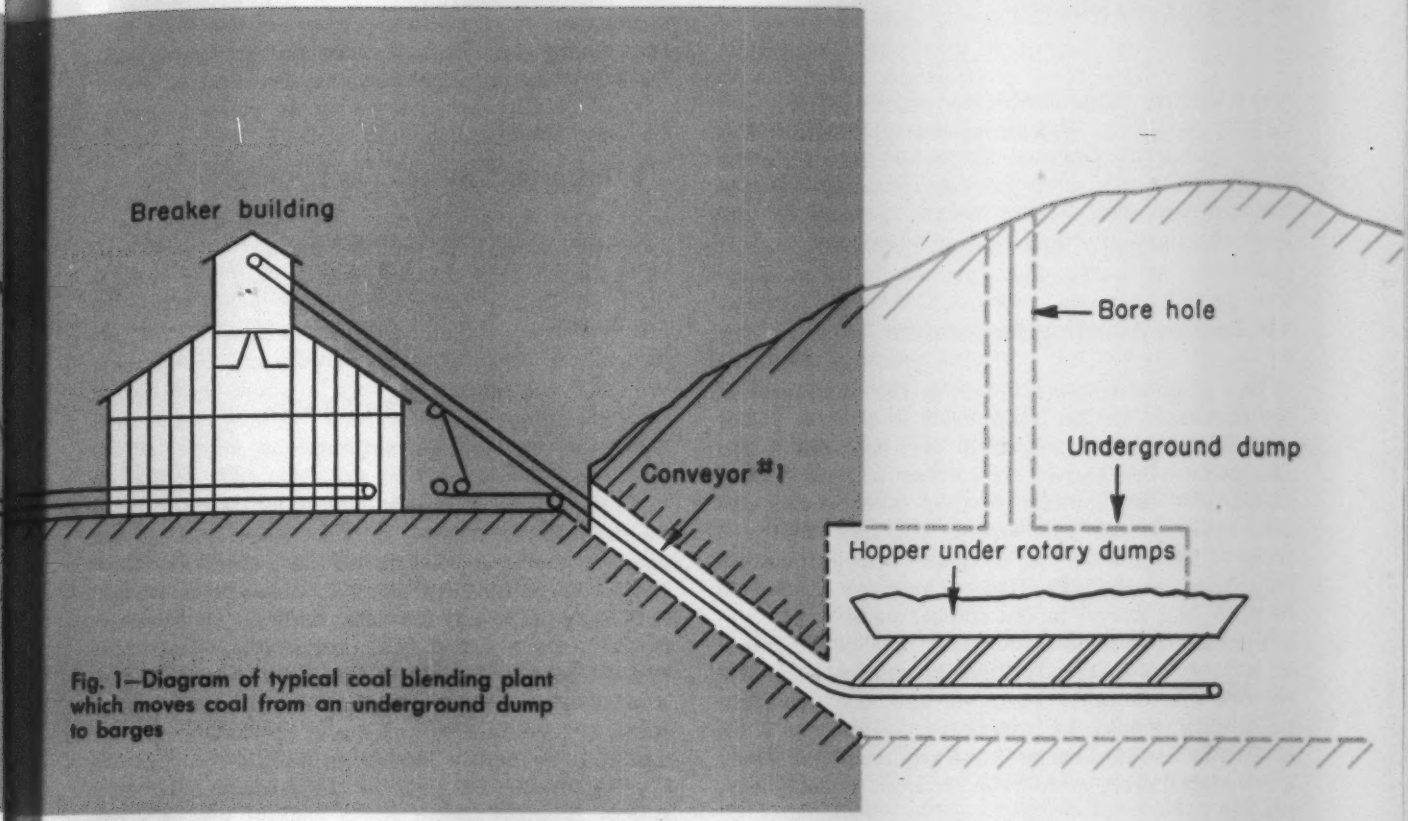

Fig. 1—Diagram of typical coal blending plant which moves coal from an underground dump to barges

HEAVY MATERIAL HANDLING USES AUTOMATION

By E. H. ABBE
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General Electric Co.
Schenectady, N. Y.

Accurate sequencing and closed cycle control are featured in latest installations handling materials such as coal, stone and ore

IMPENDING ADVENT of the automatic factory has brought new terminology into being. Automation, the keyword of automatic production, means *continuous automatic production.* It is operation without the guidance of a human hand. The term should not be applied to a single step in a process, at least two steps should be performed automatically before the automation area of operations begins. Automation is not simple mechanization such as a coal breaker. As soon as we add transfer devices to a breaker for instance, a feeder conveyor and a discharge conveyor, the combination of the three becomes automation.

The ever increasing demands of an expanding technology makes it necessary to handle the basic materials, ore and coal, more quickly, *Fig.* 1. The growing use of conveyors coupled with high speed loading and unloading equipment has made possible much faster handling of such heavy materials

and also has complicated the control of the machinery involved. Although many of these systems have automatic features, there are no completely automated heavy material handling installations for ore and coal in use today. Several factors limit the possibilities of such installations.

Factors Affecting Automation

The most important factor is the judgment of the operator. In the example of an electric power shovel digging into a bank of ore, how would you determine when and where to start digging? How would you discriminate between overburden and ore? How would you deposit the dug ore on a truck? The answer is obvious—full automation does not fit the situation. Judgment is needed to place the shovel in the correct position.

Another factor is economics. The development of automated material handling equipment would require considerable research and the resulting machinery would be expensive. Since each installation has its own peculiar requirements, every new installation would be a new development project.

Savings in labor and time might be quite high, and must be determined by a thorough study in each case. Since very few projects of this type have been undertaken, facts and figures for typical systems are not readily available for comparison.

Important Automated Features

On the other hand, automation can be, and is, used on portions of ore and coal material handling cycles. Some examples will explain this. Equipment is now in use that provides one or both of the following features:

1. Closed Cycle Control.
2. Accurate sequencing.

To explain closed cycle control let us refer again to the electric power shovel. Assume that the operator, using his judgment, has aimed the shovel bucket correctly. By using a closed cycle circuit with automatic current limit control, the bucket is raised in the shortest time permissible. The torque applied to the bucket is limited to a value just short of the commutating limit of the motor. The speed is regulated automatically so that the bucket motor is as highly loaded as possible during the digging cycle. Damage to the machinery is prevented because closed cycle control prevents excessive torque from being applied even to the point

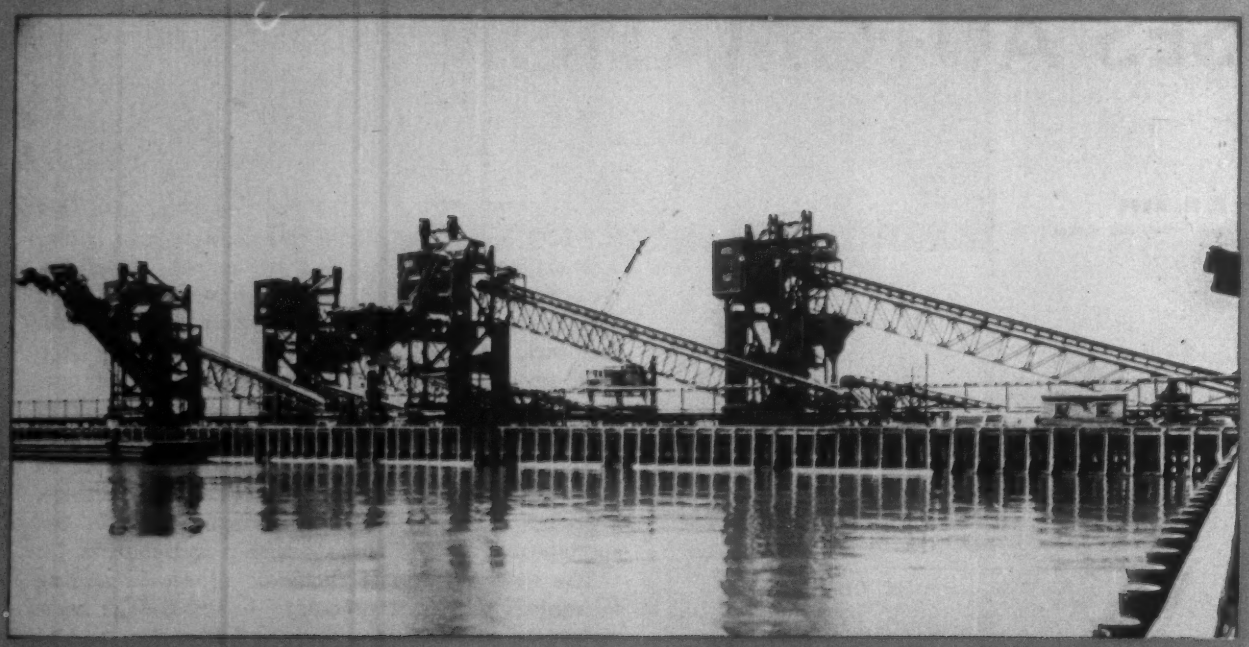


Fig. 4—View of the loading towers at Chesapeake and Ohio Railway Pier 14, Newport News, Va. shows the immense size of the system

of stalling.

Similar closed cycle control systems can be applied to the grab buckets, trolleys, and bridge drives on ore or coal unloading equipment. In like manner loading of conveyor belts can also be controlled accurately thus preventing undue wear on the belt and assuring proper transfer of material from one belt to another.

Automatic sequence control systems have been developed to control the flow of material between points. As an example, consider the system of conveyors in a coal preparation plant. Through the proper sequence interlocking the starting and stopping of the various conveyor belts are so controlled that material flow is automatic. The system shown in *Fig.* 1 is a coal blending plant in which coal is moved from an underground dump to barges. The sequence provides a conveyor from the dump to the breaker building and from there to the blending bins where the coal is deposited on a shuttle conveyor. The shuttle conveyor permits correct blending of the coal. Another series of conveyors then takes the blended coal to the barge loading facilities.

Another interesting example of sequencing is demonstrated in the coal loading facilities for ocean-going ships at the Chesapeake and Ohio Railway Pier 14 at Newport News, Va. *Fig.* 2 shows the rotary car dumpers where the coal is dumped into large hoppers from which it is discharged onto the conveyor belts. A general view of the long conveyors leading to the loading towers is shown in *Fig.* 3. Trippers and inclined conveyors take the coal from the belt to the top of the tower where it is transferred to another belt leading to the end of the loading boom. The four loading towers are shown in *Fig.* 4. Proper sequence interlocking is required to prevent spillage at transfer points and to insure a smooth flow of coal.

More recently considerable advance has been made in automatic program control of blast furnaces. In *Fig.* 5 is shown a proposed layout that would permit a completely automated scheme for charging a blast furnace. The system would be under the control of a program unit which can be preset to supply the correct sequence of loads of ore, stone, and coke necessary to properly charge the furnace. The heart of the system is the skip hoist into which the scale car (to insure correct batching) automatically discharges. During each trip of the skips the scale car will travel automatically to the called-for storage or surge bin and will automatically have the correct amount of the pre-selected material loaded into it. The control will also correctly position the material on top of the furnace in the proper annular locations by means of the furnace top bells and rotating distributors. *Fig.* 6 shows a general view of a typical blast furnace with the skip hoist going up its side, the stock house at the bottom of the skip way, with storage facilities and an ore bridge

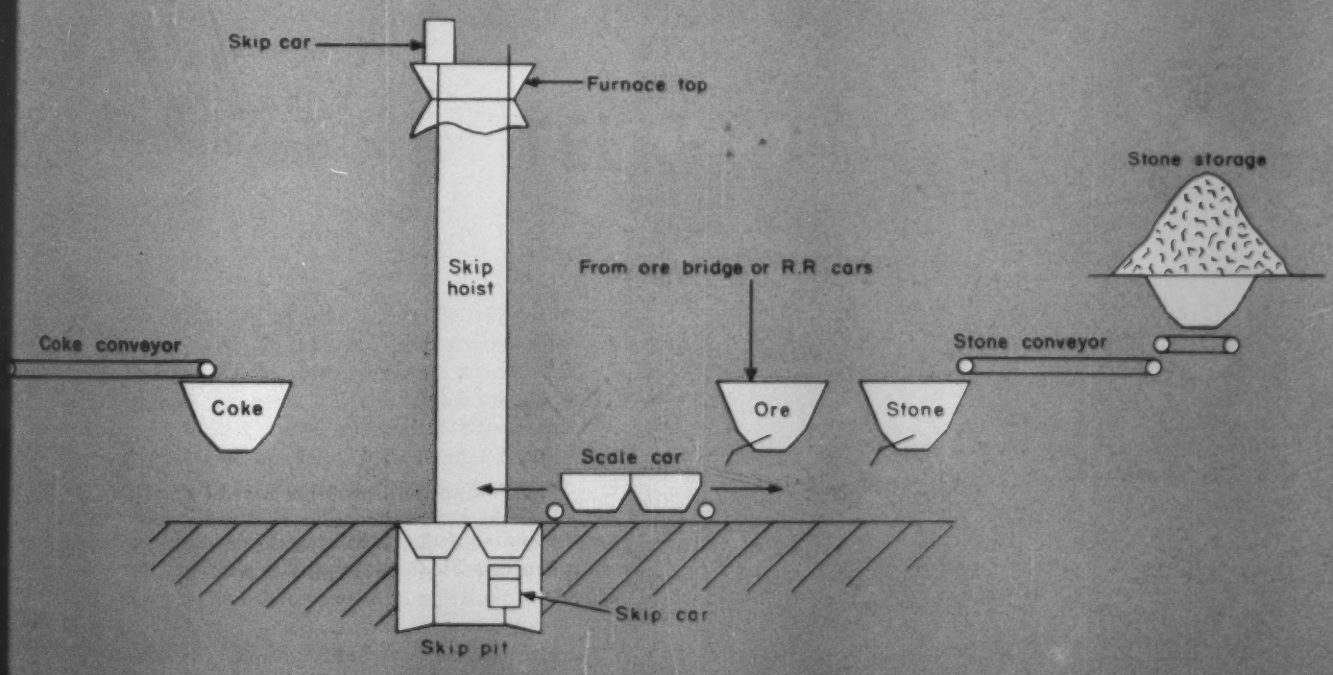


Fig. 5—Proposed layout for atomated blast furnace charging

in the foreground. The illustration in *Fig.* 7 depicts a program control panel.

Safety and Maintenance

A word of caution is in order when considering automation. Safety, for both the machine and the operators, is important. Adequate means for bringing the machine to a quick stop must always be provided. Proper devices for locating and signaling trouble such as overloads, improper operation, faulty machinery, must be used to initiate the stopping cycle. Personnel must be properly protected from the fast moving machinery.

With automation of the machines, wear and tear is reduced by eliminating jogging (because accurate positioning can be accomplished), by eliminating undue stress and strain (because of accurate speed and torque characteristics), and by eliminating mistakes (because of correct sequencing). Result is less maintenance and down time.

Conclusion

Looking to the future the further use of automation in heavy material handling will relieve the operator and will help prevent accidents, especially those due to human failure. At the same time, by so relieving the operator, it will give him more time to properly manage the equipment, select the correct flow patterns and to achieve a faster cycle of operation.

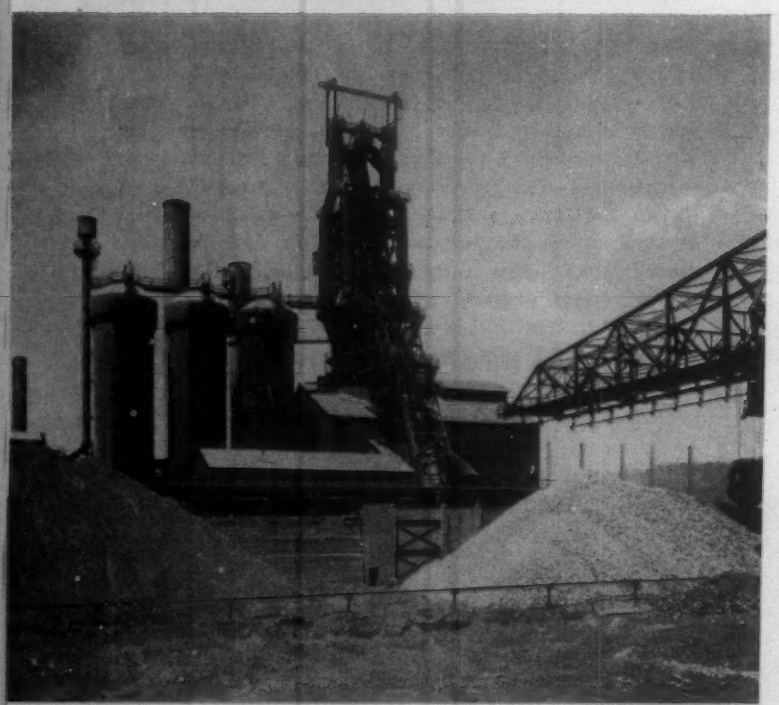


Fig. 6—General view of blast furnace installation, Crucible Steel Co., Midland, Pa. plant, engineered, designed, and erected by John Mohr and Sons

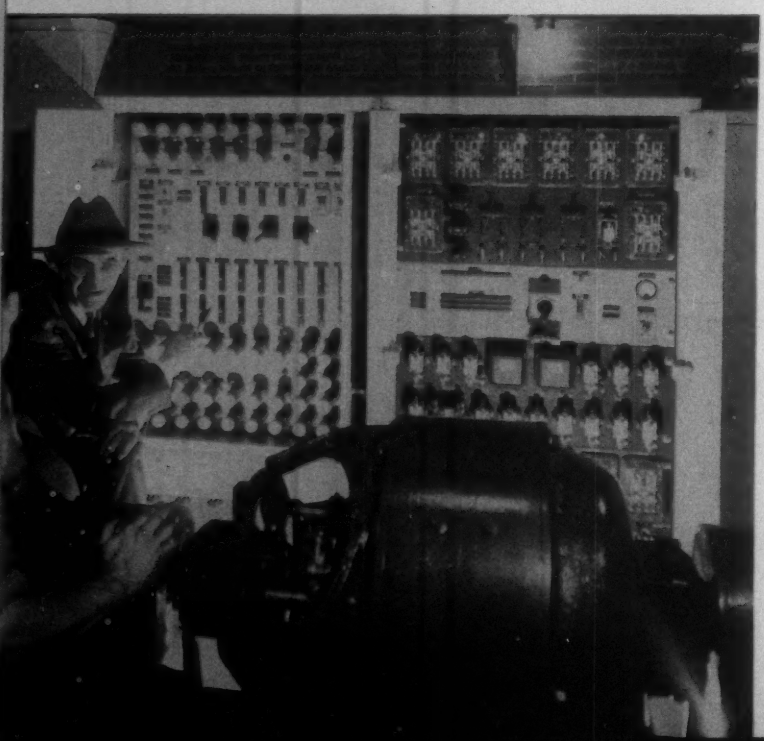
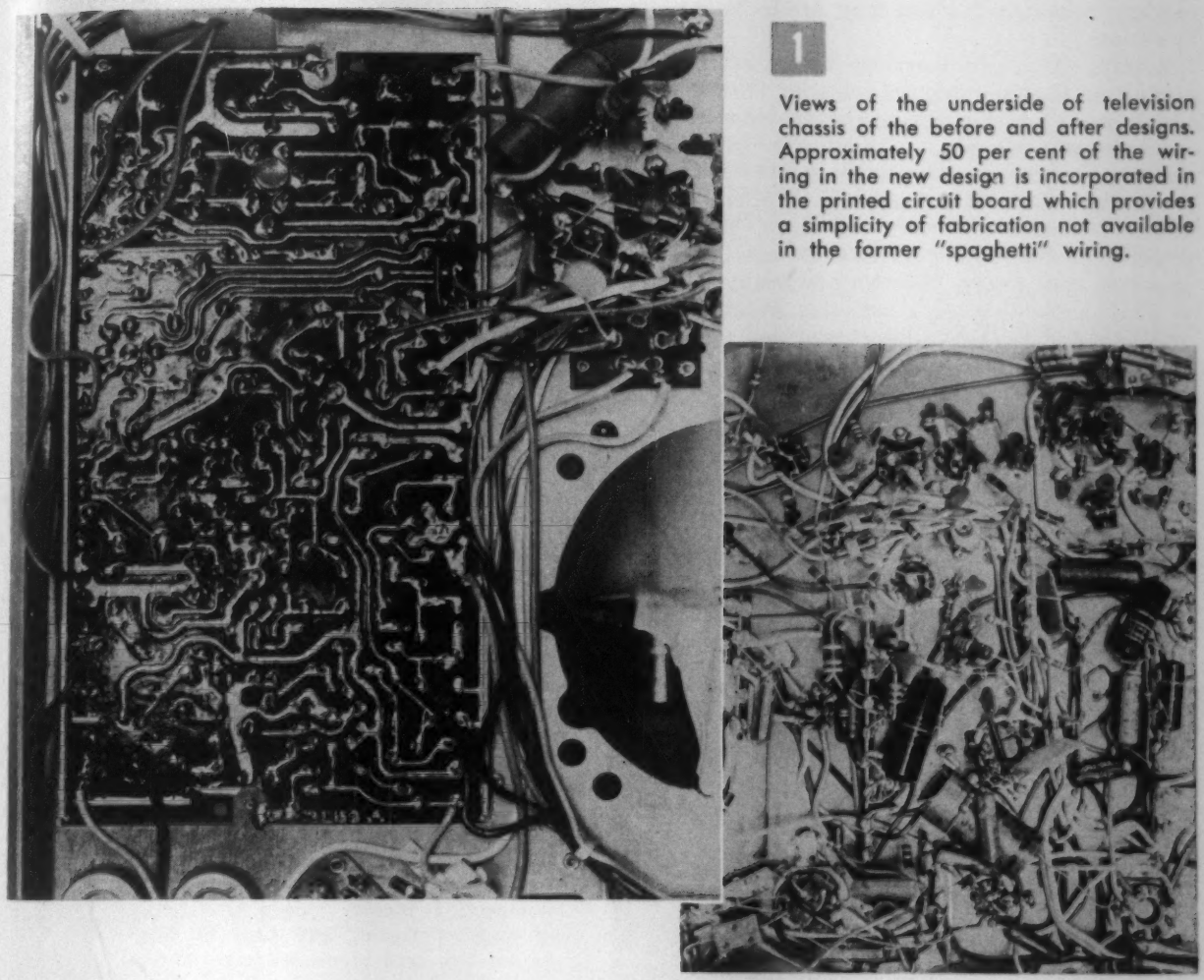


Fig. 7—Charging program control panels built to the engineering design of John Mohr and Sons for installation at the Crucible Steel Midland, Pa. plant



1

Views of the underside of television chassis of the before and after designs. Approximately 50 per cent of the wiring in the new design is incorporated in the printed circuit board which provides a simplicity of fabrication not available in the former "spaghetti" wiring.

AUTOMATION TODAY

FABRICATING TELEVISION CIRCUITS

DESIGN FOR MANUFACTURE is a theme of modern industrial philosophy that is a cornerstone of the structure of automation. An outstanding example of the redesign of a product to facilitate more automatic production techniques is found in the application of printed circuit boards as a television chassis component. The 30-foot mechanized production line designed by Admiral Corp. engineers automatically assembles parts to the basic printed circuit board in a manner that was impossible with the former "spaghetti" wiring design.

Boards are photo-etched and stamped ready for this operation where they move automatically from station to station down the line. Fifty assorted resistors and wire jumpers are automatically chute fed and inserted in the board, some singly, some two at a time and some three at a time. The development of this process of manufacture required the redesigning of components so they would fit into the feeding chutes. Before inserting the resistors, the mechanisms trim the wire leads to size and crimp them precisely to contact the copper circuit pattern.

Upon completion of this automatic phase of the fabrication, eight tubes are hand assembled to the board and the wiring connections on the underside are made fast by a dip soldering operation. The circuit is then ready for assembly to the chassis.

Process and equipment shown in the accompanying pictures are said to be only the beginning of a modernization program. Two other machines,

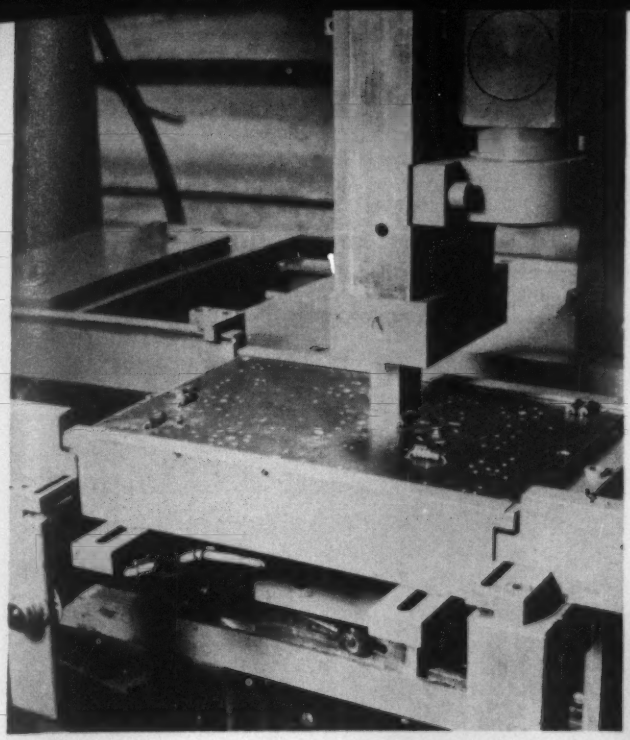
one approximately 100 feet long, are to be put into operation.

Results have been favorable to the extent that production is more uniform; soldering trouble free; circuit has greater resistance to extremes of temperature and humidity; design has more engineering flexibility; production quantities are up (requiring additional employees in other phases of the business) and costs are down, permitting prices to be lower. John Huarisa, the executive vice president, has stated, "There's practically no limit to what automation can accomplish, eventually the machines will be able to insert such complex items as tube sockets and tubes."

2 First step in producing the printed circuit is photographing a large drawing of the circuit layout to reduce it to a sharp actual-size negative. The negative is then placed in a printer as in any photographic process, and the "picture" is printed on an aluminated plastic sheet, one side of which is covered with thin copper foil.

3 Printed circuit boards are inspected and retouched. These will later be cut, trimmed, and punched with holes to mount the wires and various electrical components.

4 Employee in foreground holds boards showing (left) soldered connections and (right) top side with parts that are automatically assembled by the 30-foot long machine in the background.



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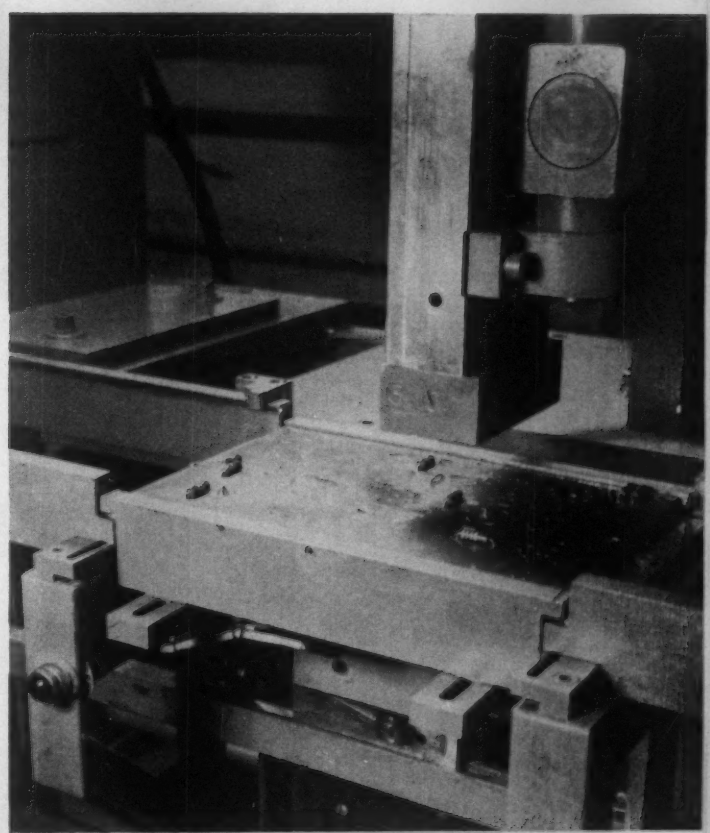
At this work station a jumper wire is being inserted into the circuit board by the chute fed head. All stations are electrically interlocked and the entire machine is pushbutton controlled.



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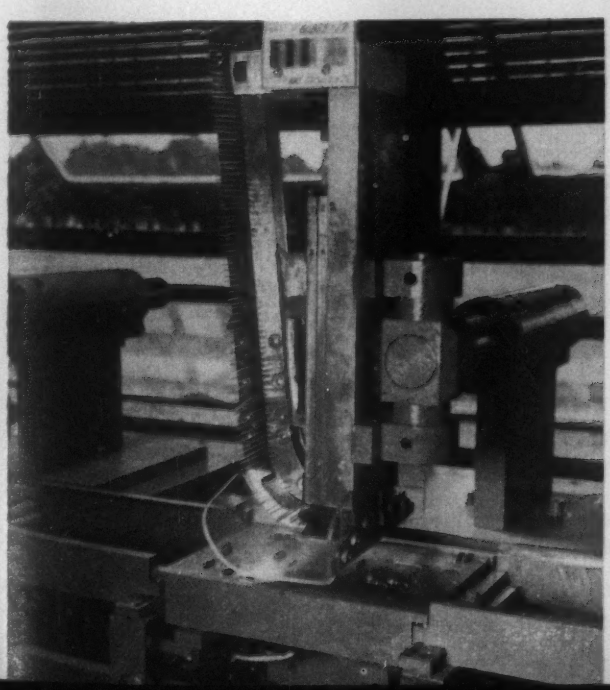
Head is shown retracted and jumper wire is in place. Should a component fail to feed into proper position the entire machine would stop and the red light at the lower left would signal which station was in need of attention.



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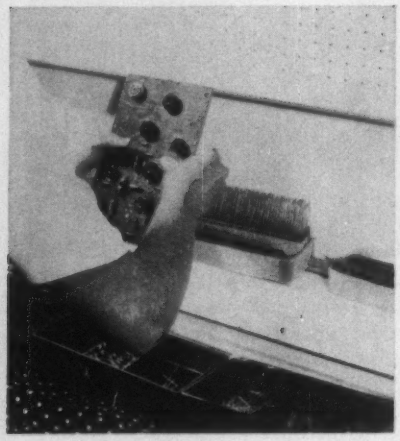
Boards are automatically moved from station to station on the line. This head passes the leads of a resistor through two punched holes and crimps them on the underside.

8

Final hand assembly operations include (left) this insertion of additional large resistors and (below) the assembly of eight tubes in the circuit board. This completes the assembly of 77 components.



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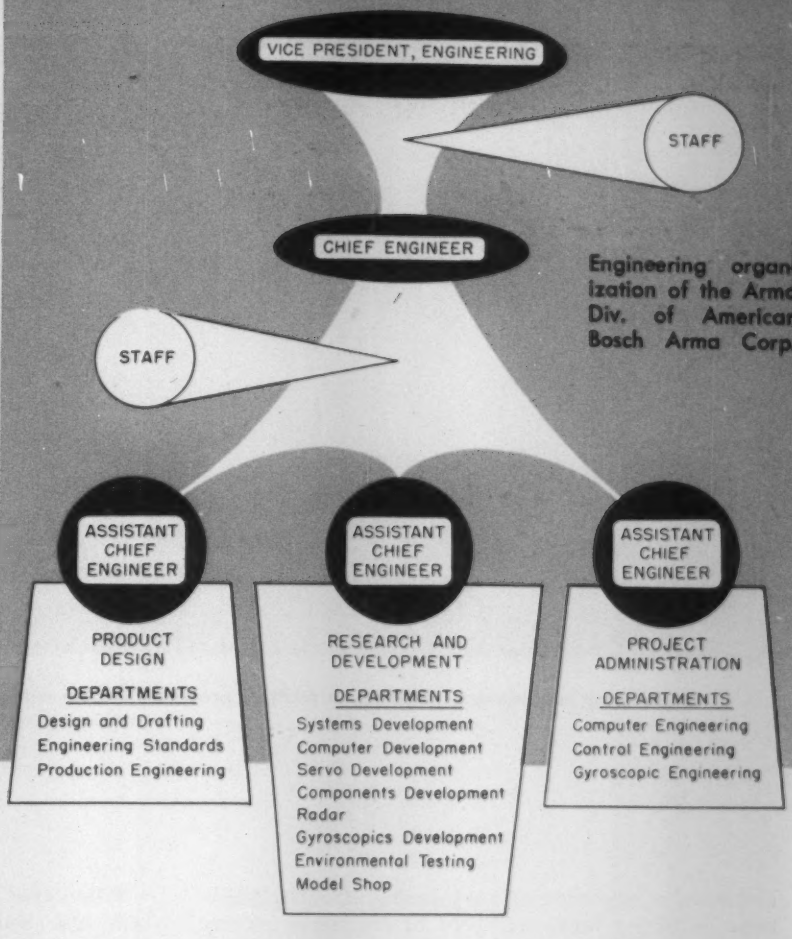
Underside of the board is dipped in molten solder a few seconds to connect the crimped ends of the leads to the copper pattern of the printed circuit. This type of soldering is trouble-free and eliminates the complications of hand soldering methods.

10

After critical inspection by technicians, the eight-tube printed circuit section, which was produced by automation, is mounted in the metal chassis pan for an Admiral television receiver.

PART 1—Plans for automation involve broad thinking in overall operations as well as detailed layout of the component equipment. In a series of three articles the aspects of applying large numbers of variously specialized engineers to projects of great complexity are considered from the administrative viewpoint. Organization, scheduling, measurement, and control of engineering effort must rank with individual technical ability if success is to be achieved



Engineering organization of the Arma Div. of American Bosch Arma Corp.

By E. D. GITTENS
Chief Engineer, Arma Div.
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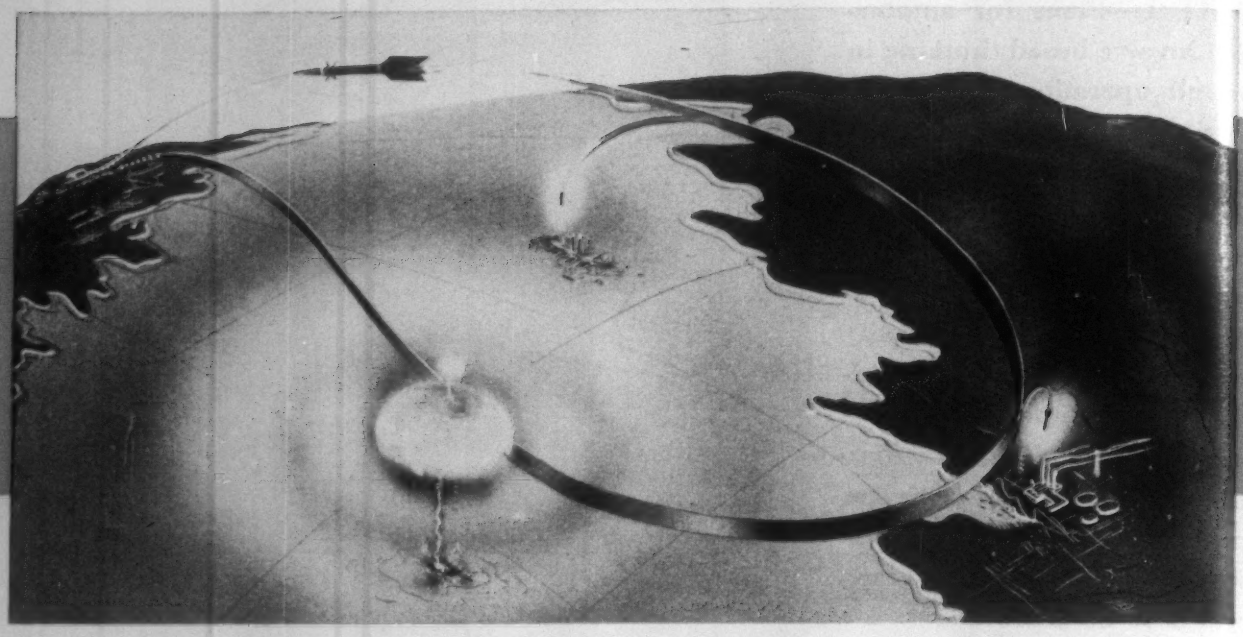
MANAGEMENT OF SYSTEMS ENGINEERING

A NEW CHALLENGE

IT WAS NOT very long ago when one man either alone or with the help of a few assistants could produce a milestone in technical progress such as a cotton gin, a steam locomotive, or an automobile. Today such possibilities still exist but they are becoming increasingly rare. Great technical strides are still being made, but they are coming about in a different and highly significant manner—through highly co-ordinated engineering effort involving many engineering groups and specialties. As we look around us we see abundant evidence of a civilization marked by a new high in technological achievement which has become so commonplace as to be taken for granted. Today, interplanetary travel is within our grasp. If a sufficient need existed at this moment, a successful solution to such a problem could be obtained. The tools are at hand—and one of the most basic of these is a relatively new concept of engineering application and management called "systems engineering."

What It Is

What is "systems engineering"? To some it may be a new term and to others—particularly today's young engineer trained in an atmosphere of automatic computers and controls—it is an old story. "Systems engineering" may be broadly described as a management means of producing a highly co-



Engineering requirements of modern military problems involve a high degree of systems engineering

ordinated application of engineering effort to problems requiring large numbers of engineers having varying degrees of specialization.

One use of systems engineering which has come dramatically into view in recent years is in the field of automatic controls. Systems engineering, in this particular area, has a range and scope which broadly embraces the design, development, and production of automatic controls for aircraft, industrial processes, communications, ordnance, and navigation—not in terms of automatic machines or devices alone, but as fully co-ordinated solutions to operational problems.

A clearer concept of systems engineering might best be obtained through a description of a typical project falling within its scope: Such a project might be the design, development, and quantity manufacture of a bomber defense systems for warding off the attacks of modern, high speed fighter aircraft. Generally such a problem is presented to a company in its broadest aspects—there being little more to start with than the stipulation by the customer that such a system is a tactical requirement for a particular airplane. Before the company's engineering staff can develop a basic approach to a solution, it must begin by making extensive studies of all aspects of the problem such as basic analyses of tactics, weapons, aircraft configurations and performance, and the state of the art of aircraft offense and defense. During the formative phase of the program careful consideration must be given to the availability of components and instrumentation techniques which are planned for use—since the entire project is usually tightly bounded by time schedules and cost.

When the basic concept of an appropriate solution has been determined through analysis and study, the project then enters the design phase wherein the planned approach is set forth on drawings in its "hardware" form. This stage necessitates careful attention to cost, weight, stress, materials, performance specifications, production engineering, reliability, and maintenance in order that the end product will satisfactorily solve the problem, be producible in quantity, and satisfactory as a usable item in the field.

Many other factors must be considered other than those broadly listed above, but it begins to be evident that such a project requires the co-ordinated efforts of many engineering specialists in such fields as theoretical analysis, research and development, stress analysis, component design, electronics, circuit design, mechanical design and packaging, quality control, production engineering, environmental testing, and so on.

All of these specialized skills must be melded into a smoothly operating, well co-ordinated team capable of solving the problem, producing the equipment within a time limit, and within a given cost.

This is systems engineering. It has opened vast new possibilities for engineering accomplishment and new horizons of prestige for the profession, but it brings with it a *new challenge* to engineering management.

Heretofore it was possible to handle automatic control problems with relatively small groups of well-rounded engineers, since the field was young and for the most part applications were simple by present-day standards.

Systems engineering requires that specialized skills be melded into well co-ordinated teamwork

Today, however, one has but to consider the difficulties and complexities involved in the control of guided missiles, industrial processes, aircraft, gunfire, and the like to realize that the requirements of this type of engineering demands a re-evaluation of the management and organizational approach to such problems.

New Challenge to Management

What is the nature of this new challenge to engineering management? Its elements are basically twofold. First is the emergence of engineering specialists on today's scene in many fields such as servomechanisms, automatic computers, electronics, and the like with their respective breakdowns into still further specialty. Each of these specialties in themselves offers the individual engineer sufficient challenge and scope to be attractive as a career.

Secondly, the engineering problems of today—and surely those of tomorrow—point toward a degree of complexity that makes it apparent that no individual engineer can be capable of coping with them or perhaps even understanding all aspects of them.

Successful systems engineering therefore requires a well-planned enginering organization and management which will yield the co-ordination necessary to combine the various engineering specialists into a successful team capable of handling the corporate objectives. Further, it must provide an atmosphere of intellectual freedom for the creative professional man and an opportunity to develop his growth potential.

Basic Requirements

In order to attack the problem of organizational management of systems engineering, one must first analyze the basic requirements of a good solution. Any good engineering management has a purpose which can be simply stated: It must accomplish its objectives on time, at a reasonable cost, and at a profit. Any organizational plan must obviously satisfy these basic purposes.

Further, a good organization must provide for leadership, planning, co-ordination, and a system of controls for continuous analysis of performance. In the specific case of an organizational plan designed around systems engineering, the aspect of the individual creative specialist playing a vital role in the overall picture must be carefully considered. He must be given the opportunity to exploit his particular talents and training while simultaneously providing him with sufficient scope of participation to maintain his interest, enthusiasm, and development.

With the above basic concepts in mind, the accepted approach to any engineering problem may be applied—break it down into its elements and analyze it in detail. First, since it is evident that organization is the means of getting work done by individuals, there must be an orderly arrangement of individual and group efforts. This may be accomplished by segregating the work through careful analysis into separate classifications and assigning authority and responsibility for these to individuals to provide management control. Successive classifications may be made within these groups to further break down the work where it

Organization must provide an intellectual freedom for the man and an opportunity to develop his growth potential

may be distributed to individuals at the lowest working level. With the work thus broken down, its control at the levels closest to the point of decision and action is possible by the assignment of competent, qualified supervisors. Such individuals should be capable of taking a direct hand in the technical work of their subdivision since their responsibility is the direction, leading, and training of the working level engineer.

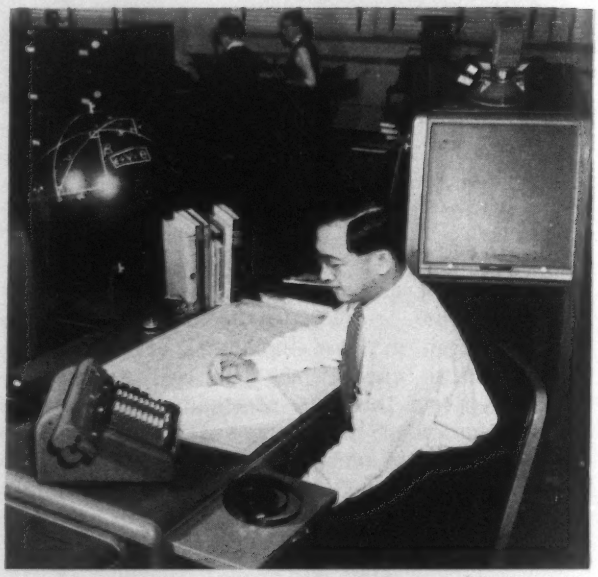
Organizational Functions

Some simple rules should be carefully observed when analyzing the appropriate breakdown of the organizational functions:

1. The organization should be built around functions and not individuals.
2. Organizational functions should be divided into the fewest number of classifications consistent with the effective handling of all the work required by the type of enterprise.
3. Organizational structure should be such as to permit each supervisor and, in turn, each of his personnel, the opportunity to exercise maximum initiative and resourcefulness with responsibilities, scope and authority clearly defined.
4. The organization should be flexible to accommodate expansion or contraction as changes in business requirements dictate.
5. The organization should permit good communication up, down and crosswise to provide effective coordination.

With an analysis thus completed and the various functional organizational units outlined, the next step is the assembly of these functions into a total organization. One such which may be of particular interest as a case example is that employed by the Arma Div. of the American Bosch Arma Corp.

For 35 years, this organization has been engaged in the field of automatic computers and control systems. During this period its engineering staff grew from a handful of well-rounded engineers to



For such work one must call upon the talents of physicists, mathematicians, and engineers skilled in many technical fields

an organization numbering over one thousand. This growth encompassed almost the complete history of automatic control systems from the early days when a servomechanism was a few simple parts known as a "follow-up" to the modern systems of the present which permit automatic control of military weapons and complex industrial processes.

The organizational arrangement of the engineering division changed continuously to keep pace with the increasing demands of an expanding industry. As time went on it became necessary to develop an organization which was adapted to the management of a large number of extensive and complex engineering programs simultaneously. This resulted in an organization suited to systems engineering on a large and diversified scale but which naturally continues to require study and modification as business operations dictate.

Basically the technical effort required in modern systems engineering may be broadly classified as falling into three general areas:

1. Project Administration
2. Research and Development
3. Product Design

With this concept in mind, the organization was subdivided into engineering sections to embrace each of the above areas. Each of these broad subdivisions was then further subdivided to reflect the individual specialties required for the operation of the particular section.

Referring to the accompanying chart, it will be noted that the organization may be generally classified as a *line* type with the major subdivisions arranged as described above.

With the vice president for engineering and the chief engineer acting in line of command, and aided by their staffs, a description of the organization is as follows:

▸ Project Administration Section

In this section is vested the administration and co-ordination of all projects such as industrial process controls, automatic machine tools, analog and digital computers, fire control systems for use on air, sea, or land vehicles, navigation and plotting systems, and miscellaneous devices of a control or computing nature.

The activities of this section are further subdivided by a breakdown into specialty departments, such as the computer engineering department, control engineering department, and gyroscopic engineering department. The primary role of the project administration section is to: co-ordinate all of the engineering activity required on a particular enterprise; deal with the customer on all phases of the work; be responsible for continuously monitoring the health of the work from the standpoint of technical accomplishment, budgets, time and schedules in conformance to the customer's requirements; and to provide engineering guidance for all design features of the equipment.

▸ Research and Development Section

This section is charged with the responsibility of performing basic engineering investigations and studies and has cognizance over all of the company's laboratories and model shop facilities. Since the activities of this section cover a very broad field of technical work, it is subdivided into a number of specialty departments which are:

Systems development department involving the work of a number of mathematicians, physicists, and engineers engaged in mathematical studies, evaluation of data, studies of methods of instrumenting the solutions to problems, and the preparation of schematic or "block" diagrams which serve as a basis for engineering designs.

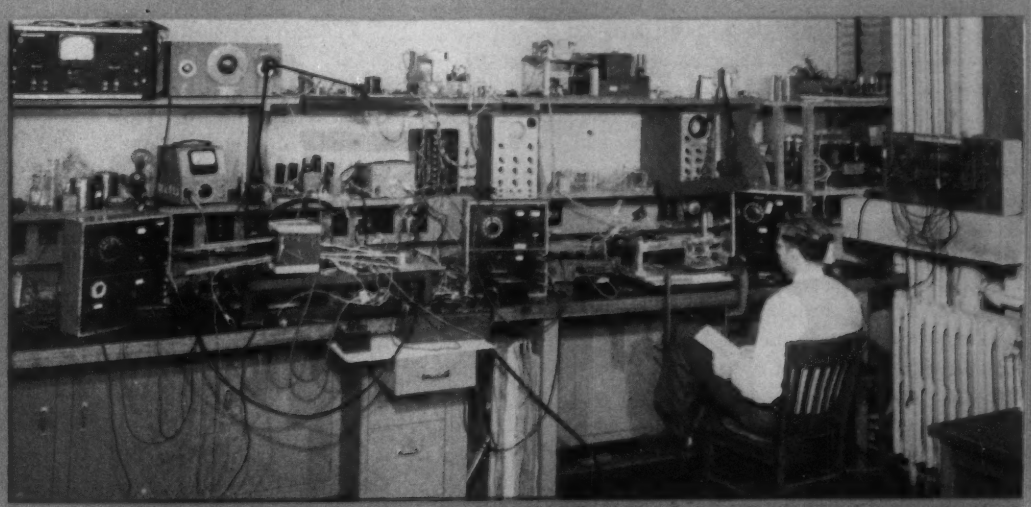
Computer development department concerned with the experimental and development aspects of mechanical, electromechanical, and electronic computers.

Servo development department engaged in experimental work in the field of servomechanisms.

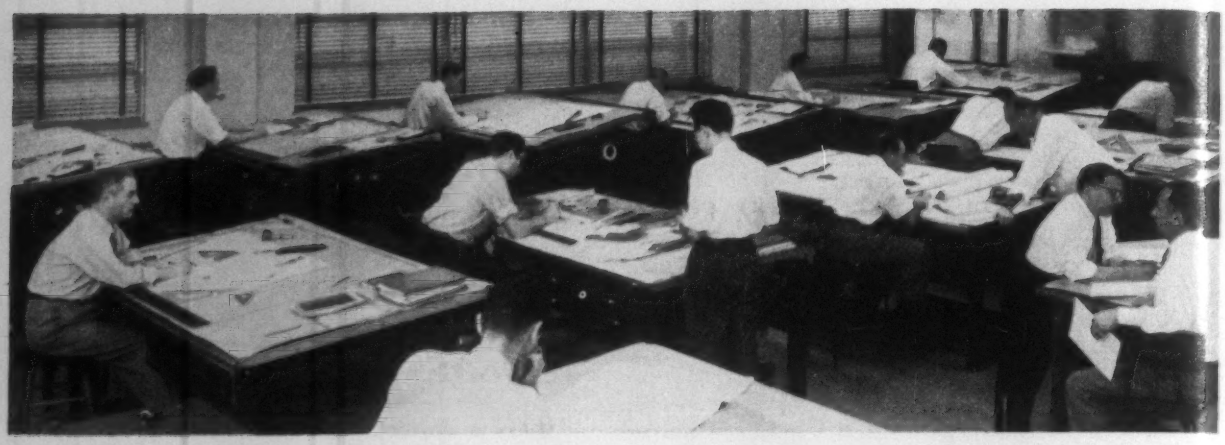
Components development department devoted to the development of all types of components required in systems and computers, such as motors, potentiometers, amplifiers, generators, etc.

Still further departmentalization is extended to include, respectively, radar, gyroscopics, environmental testing, and model shops.

Within this section and its specialty departments is found the type of engineering activity which is devoted to the basic technical philosophy and approach to a problem through the avenues of engineering study, research, and development. Here the engineering groundwork is laid for the equipment that is to be built, and the first proto-



Research and development phase of a project includes laboratory work on experimental models



Production engineering takes a leading role in the guidance of the project as the drawings and specifications are prepared

type is put through its performance tests for the purpose of "debugging" and refinement.

▶ Product Design Section

This third broad area of engineering is the point at which the technical data and requirements produced by the project administration section and the research and development section are reduced to manufacturing terms in the form of drawings and specifications. This section is again departmentalized into specialty areas to recognize the functions of design and drafting, engineering standards, and production engineering.

The philosophy and responsibility of this section is to provide the manufacturing division with engineering information and guidance in a form which is aimed at the manufacture of a product in conformance with customer requirements at a minimum cost in dollars and time.

The foregoing represents a comprehensive description of the manner in which the elements of systems engineering have been broken down and used as a means of establishing departments of specialty.

If one were to take this organization at face value and assume that projects would have to be broken down and assigned by the chief engineer according to function or specialty, such an organization would immediately be deemed unworkable.

However, it is possible for this engineering division to handle hundreds of different projects simultaneously and successfully through the concept and operation of a *project team* superimposed on the plan of specialized departments.

A project team is a group of engineers formed by drawing members from departments which must contribute to the overall effort. This group acts directly within the engeering division and by liaison with other divisions of the company. It is charged with the responsibility of the administration, budget control, design, research, and development work on the assigned project and its obligations are carried through all phases of the assignment to the final project completion in accordance with all contractual requirements.

Unification of the project team is accomplished by the appointment of one of the team members to act as *project co-ordinator*. In this role he assumes the chairmanship of the group and serves to co-ordinate all of its activities and also provides a single communication point on all project matters.

Obviously the project team, being a small group of engineers, cannot in itself completely execute a large project. Additional help must be provided. This is accomplished by having the team draw up a staffing plan which is then satisfied by assigning supporting personnel to the team from each department having a team representative.

The method of operation may best be illustrated by briefly describing how a typical Arma project would be handled.

At the inception of a new project such as a computer, the chief engineer assigns overall cognizance of the job to the appropriate section and department—which in this case would be the computer engineering department in the project administration section. Simultaneously, he requests the recommendation of team member candidates for the project team from supervisors of the cognizant department and other departments which will be required to participate in the project. In this example, other departments would be the systems engineering department, control engineering department, computer development department, and the production engineering department, since these particular specialties will all be required by such a project. The supervisors, through joint consultation, then propose a project team and recommend one of the group as project co-ordinator. Upon ap-

Projects must be carried through all phases of the assignment in accordance with all contractual requirements

proval by the chief engineer, the project team is officially established and commences work.

Team in Action

The team's first approach is to completely digest the customer's requirements in all of its aspects and to propose a budget and staffing plan for team operation. This data is then approved by a committee of their respective supervisors and the team is provided with the necessary supporting staff.

The *first phase* of the team's engineering work will consist of engineering studies to develop the approach and type of solution required. This might be classed as the engineering foundation of any project, and it often encompasses considerable research and invention. For such work one must call upon the talents of physicists, mathematicians, and engineers skilled in many specialized technical fields.

At this point in the project, such work is done primarily in the reseach and development section where these particular talents and the necessary laboratory facilities are concentrated. Here one finds the team members from the systems engineering department and the computer development department assuming prominent roles in guiding the work and supplying additional support and talent from their respective departments.

The final result of this particular phase becomes the accomplishment of a practical solution to the problems involved, both as to mathematical form and the general method of instrumentation. Experimental models would have been built to prove out new ideas and new components would have been developed as necessary. This is the framework of the engineering structure to which may be added the additional engineering required to complete the project.

Next begins the *second phase* of the team's engineering effort leading to the expression of the technical work already accomplished in terms of preliminary equipment layouts and designs. At this point the prominence of particular team members in the guidance of the engineering effort shifts to the members from the project administration section.

It now becomes their responsibility to conduct design studies which will later form the basis for the preparation of manufacturing drawings.

In the *third phase* we find the team engineer from the production engineering department of the product design section taking on a leading role in the guidance of the project as the drawings and specifications are being prepared for the manufacturing division. He is vitally concerned with the project at this point from the viewpoint of production, being ever alert to the problems of manufacture and production costs. He is prepared to follow through as engineering liaison with all phases of manufacture and assembly and to act as the team contact with all production problems.

Throughout the entire project life, the project team is completely identified with all phases of activity ranging from customer contacts to engineering design and development, production engineering, test, and final field evaluation. Further, administration of the project is carried on by the team member from the project administration section to insure adherence to performance requirements, budgets, and schedules.

Thus it begins to become evident that through Arma's functional departmentalization, it is possible to arrive at a high degree of concentrated specialized knowledge and yet maintain flexibility of application through the project team operation.

Further, individual engineers are permitted to enjoy a broad experience and exposure to many specialties through their project team participation. In addition, it provides a professional atmosphere in which an engineer can find opportunity to express his individual talents in whichever direction he may find himself particularly suited. Likewise, engineering management is provided through the team operation with an excellent means of surveying its enginering ranks for future supervisory material.

The previous description of the project team concept is very brief and cursory and glosses over such important questions as the delineation of individual team member responsibilities and authorities, and the relationships of departmental supervisors to the team operations. Obviously, without careful attention to these aspects of organization and operation, the project team concept would encounter many serious pitfalls and obstacles to effective operation. Such problems and the techniques of administrative control will be the subject of subsequent articles.

Part two of this series of three articles on systems engineering will be published in the next issue. It will cover the detailed operation of the project team and the considerations which underlie its formulation.

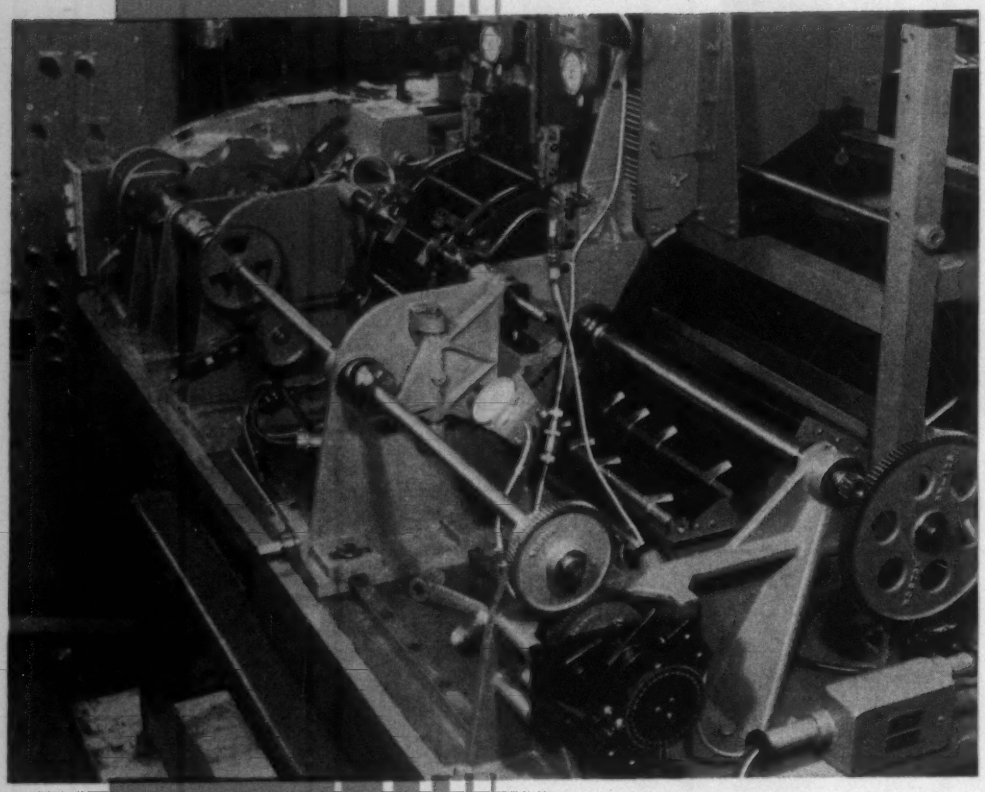


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Fig. 18 — Automotive pushrod line showing gage installed immediately after cutoff operation to measure length and OD at each end of part. From cutoff machine, conveyor feeds parts into the process control gage hopper for inspection

GAGING FOR

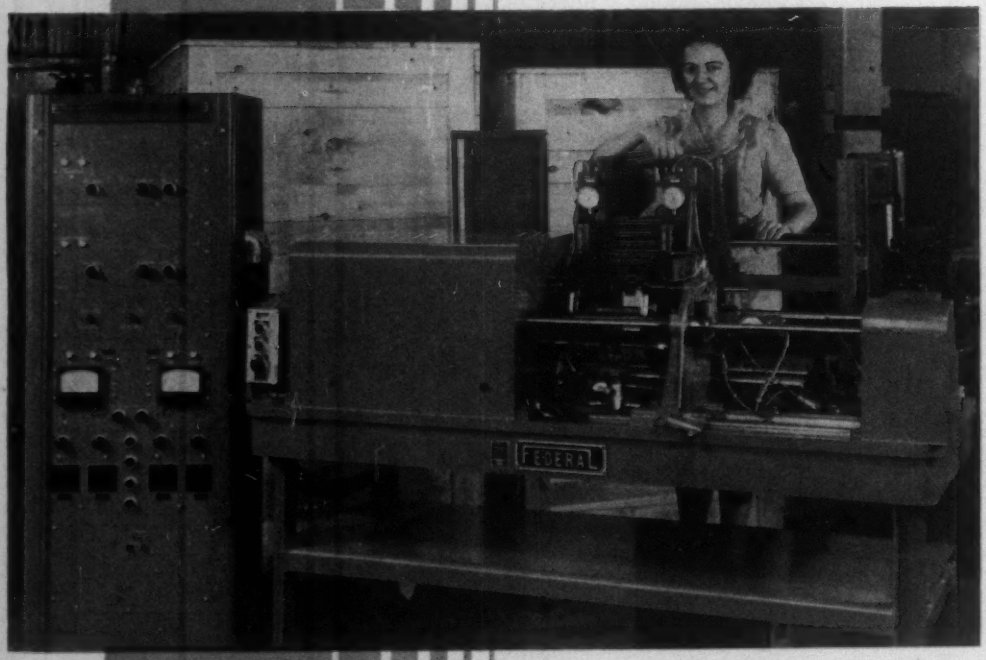
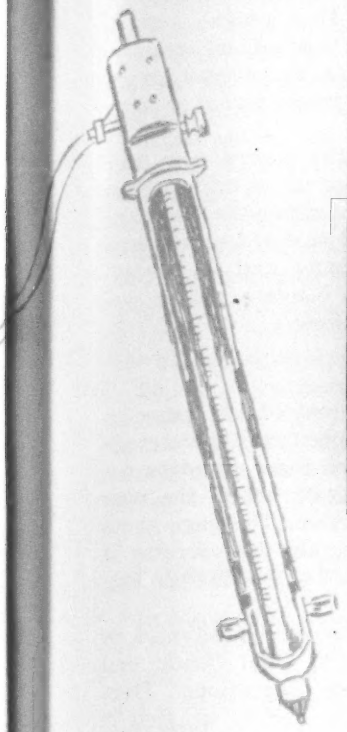


Fig. 19—Operator simulates loading final inspection machine. When installed in line, unit is conveyor fed. Final inspection machine provides a complete quality check on each finished part



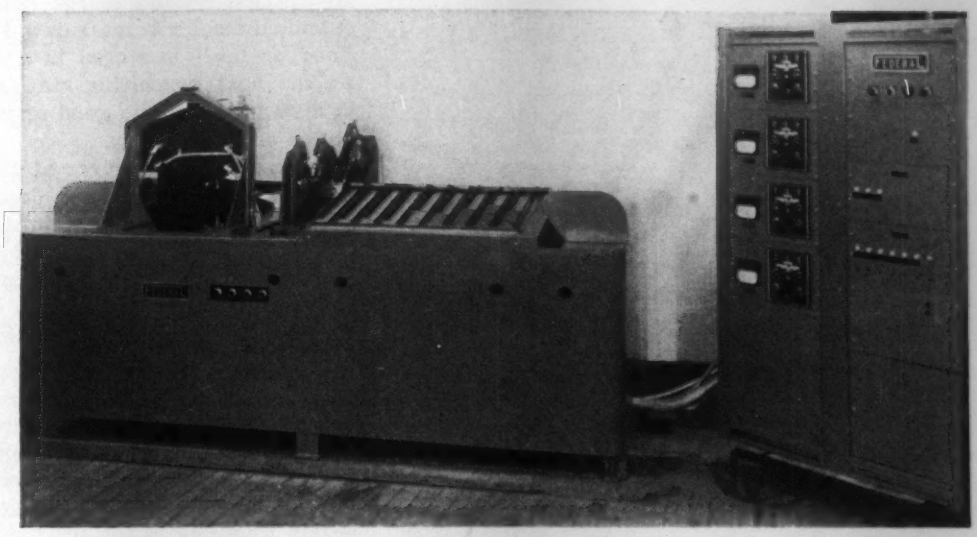


Fig. 20—Process control sorting gage accepts wristpins and measures overall pin length, hardness, full length diameter, taper, and out-of-round

PROCESS CONTROL

Final of a series, this article shows applications of gages that inspect and sort all parts at critical stages of the process and stop production machines when unacceptable percentages of rejects are being produced

CERTAIN TYPES of operations or manufacturing processes such as stamping, forming and screw machining are not suited for machine control as such. Generally, gaging is practical following critical operational steps in the production sequence. In one case, completely automated lines were set up for the manufacture of pushrods with process control gages in the line after each important series of operations.

Forming, Welding and Machining

In the manufacture of automotive pushrods, strip stock, perhaps 1 or 1¼-inches wide, is rolled to form tubing. The seam is welded, the tube runs through straightening rolls and then is cut to length. Depending then upon the type of pushrod being produced, subsequent processing varies.

Some types of rods have the ends burnished over to form a projecting hemispherical end. Before the ends can be burnished they must be faced and chamfered to remove some of the excess material. Other types of rods have inserted cup or ball ends. Tubing ends of this type are faced off and counterbored to receive the insert. Gaging on both of these lines is essentially similar.

A gage, as shown in *Fig.* 18, is installed in the line immediately after the cutoff operation. The parts are conveyor fed from the cutoff machine into the process control gage hopper. From this hopper they travel through an escapement into a notch in the pair of indexing carrier wheels and

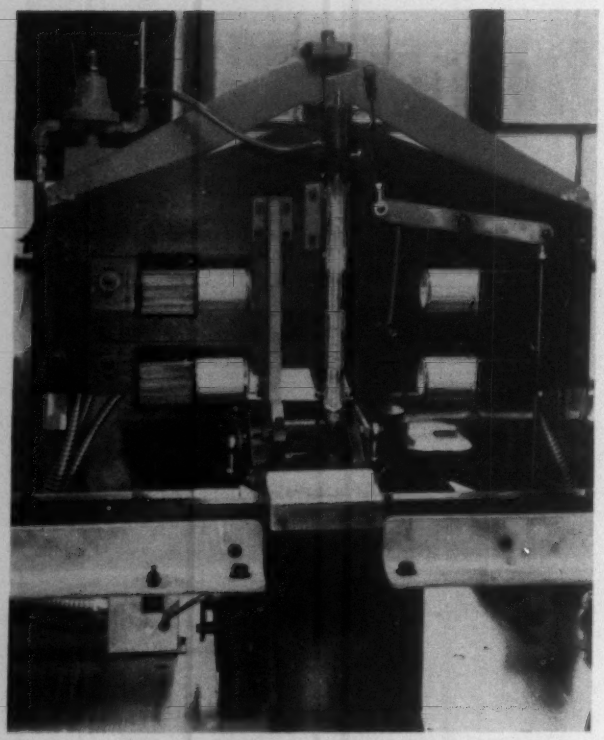


Fig. 21—Length measuring and hardness checking station of gage showing arrangement of Sclerescope and photoelectric means for automatically inspecting wrist-pins. Reject chute in foreground is for soft or off-length parts

are carried around to the first station where the outside diameter is measured. Here a signal—either *Good* or *Bad*—is stored in a mechanical memory. At the next measuring station the overall length is measured and the good or reject signal is again stored on the memory.

When the part arrives at the correct trap door the memory causes that door to operate. This passes the measured part into either the *Reject* or the *Good* disposal chute. The rejected pieces drop into containers beneath the gage, and the acceptable pieces are passed onto a conveyor which carries them to succeeding operations.

Percentage Counting

This gage as well as the rest of the gages in this production line are equipped with percentage counters. It is possible to set these counters for any given percentage of defects which the user deems tolerable in his production. The gage shuts down the entire line and signals the operator if the number of defective pieces exceeds the percentage set on the counter.

A gage of similar appearance is positioned in the line immediately after the final facing and counterboring or chamfering operations. Here again the overall length is checked to see that it has been turned to the correct specifications, the counterbore is checked for diameter to a given depth. The OD of the rod is again checked at the ends to see that there is no swelling from possible dull chamfering or counterboring tools, and the rod is checked for straightness. Here again the size impulse from each station is stored on a mechanical memory and at the correct time the part is passed out of either the *Good* or *Reject* chute. Acceptable parts continue on through sub-

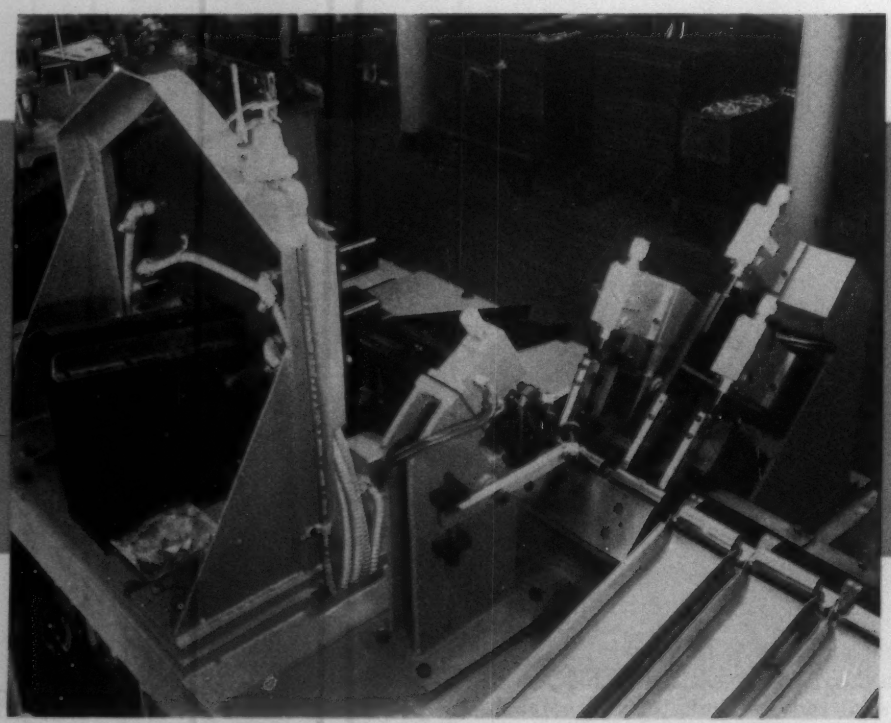


Fig. 22 — Conveyor chain brings good parts from hardness station to opposed heads which measure out-of-roundness then on to heads which check diameter and taper

sequent operations. When parts are completed, they are conveyor fed into the hopper of the final inspection machine.

The final inspection machine, which is shown in *Fig.* 19, provides the final check on quality of the finished parts. It checks the overall length of the finished rod, the outside diameter at the ends to see that there is no swelling caused by burnishing; checks straightness again to see that the rod did not become bent in one of the operations and electronically checks hardness of the ends. The gage operation is similar to those previously described; good parts continuing from the gage into the packaging equipment.

This type of operation is almost completely automatic. Starting with strip stock at the beginning of the process, the material continues entirely through the process until packaged, without again being touched by human hands.

▸ Machining, Grinding and Lapping

In some production processes it is not practical to attempt to produce all parts within the extremely close limit required. To do so would require many uneconomical additional machining operations. An example of this type of process is the manufacture of wristpins.

Bar stock is fed through multiple-spindle automatics—drilled, turned, chamfered and cut into two lengths. These green parts are sent directly to hardening or rough ground and then sent to hardening. After hardening, parts are loaded into a hopper which orients them end to end and feeds them into a centerless grinder. From the first centerless grinding operation, they pass onto a conveyor and through a series of centerless grinders and laps.

It is possible for signaling gages to control within about 0.0002 or 0.0003-inch the overall size spread of the parts as they leave the centerless lap. However, for use in automotive assembly lines, it is necessary that the parts be grouped into total spread of 0.00005-inch. Since it is impractical to try and hold this narrow spread in processing, a separate gage is used. After the parts leave the final lap they continue on a conveyor through an automatic washing device and into a process control sorting gage.

This gage, shown in *Fig.* 20, accepts the wristpins as they come from the washer, measures overall length, hardness (*Fig.* 21), diameter over the full length, taper and out-of-round (*Fig.* 22), of each and every wristpin produced. The parts which come within the total allowable spread of 0.0002-inch are subdivided into one of four groups with 0.00005-inch variation.

The various defects are sorted separately and provided with separate signaling devices, *Fig.* 23. By separating the defects in this manner it is possible to indicate to the operator that a certain defect exceeds the allowable percentage, or to automatically stop the feed through the process so that no more defective pieces enter the line bar until the process is corrceted.

After leaving the sorting gage, the parts continue again on conveyors through automatic rust inhibiting oiling devices into the packaging equipment. In the examples cited, the gages are an essential part of the process. Process control gages examine parts which are produced at each individual operation so that jam-ups will not occur during subsequent operations, and also to insure quality of the finished product.

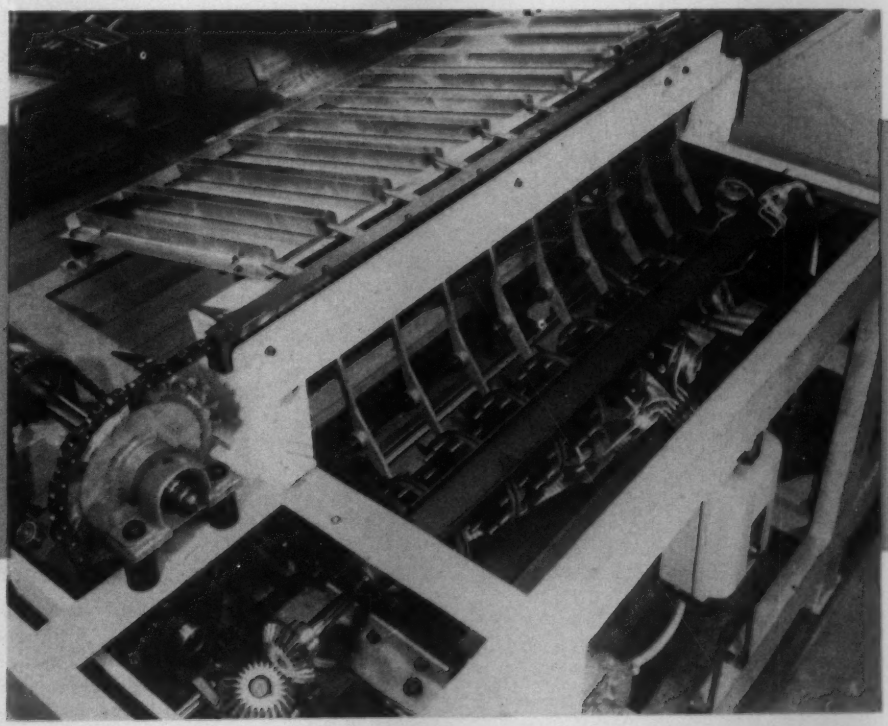


Fig. 23—Signal from classifier actuates solenoid to depress pin in memory disk. When part is in front of correct disposal chute, displaced pin is in position to operate lever tipping the trap door

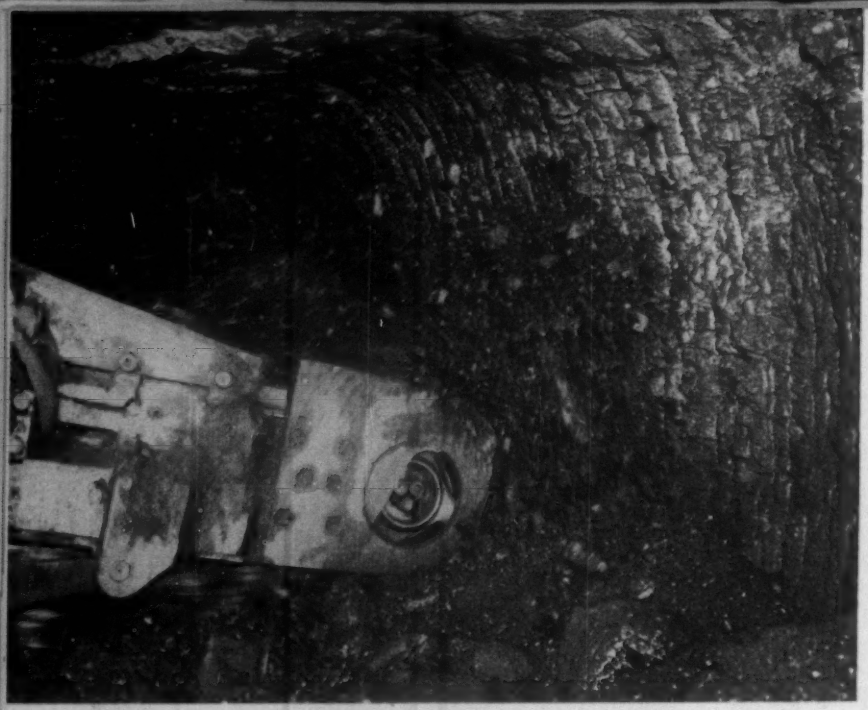


Fig. 1—Making the coal fly. Head of the continuous miner chews into the seam and starts the coal on its conveyor trip. Carbide-tipped bits mounted on electrically powered chains rip coal from the wall

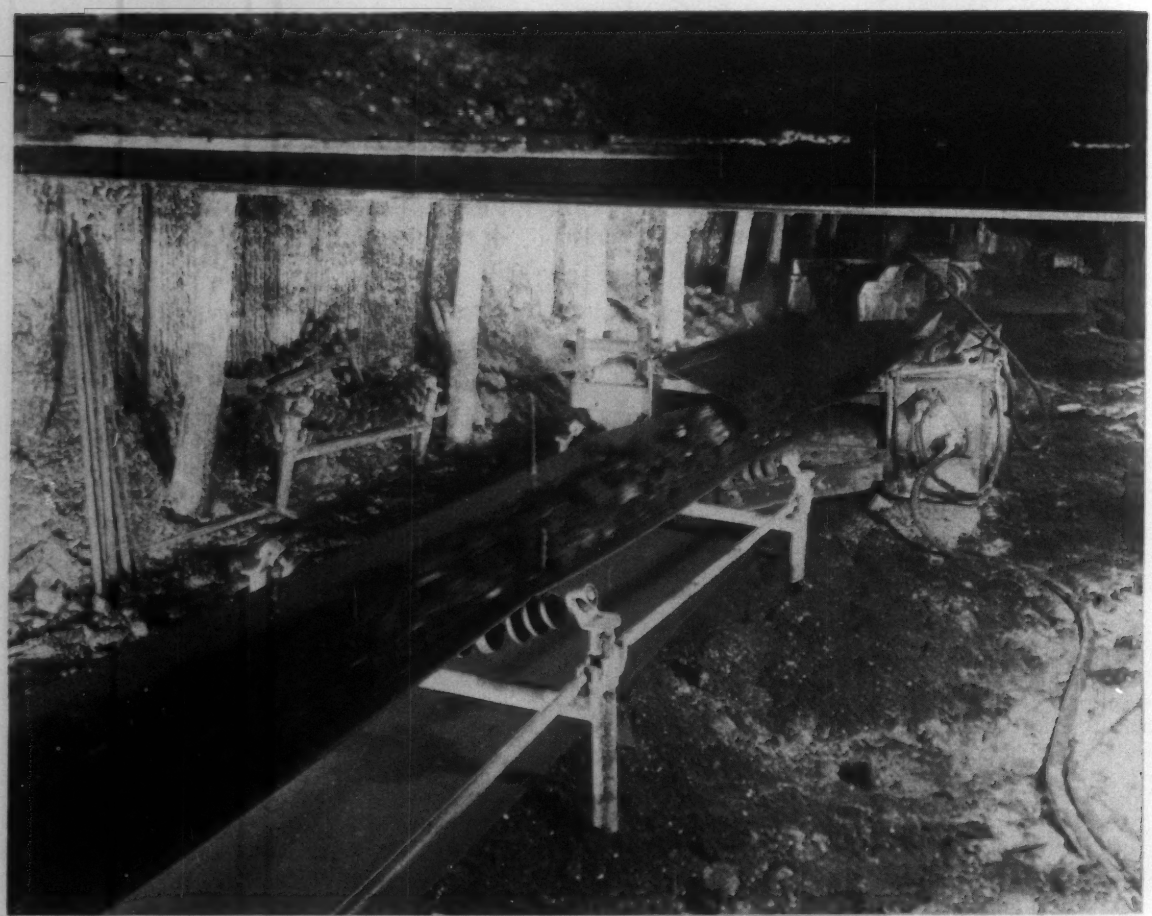
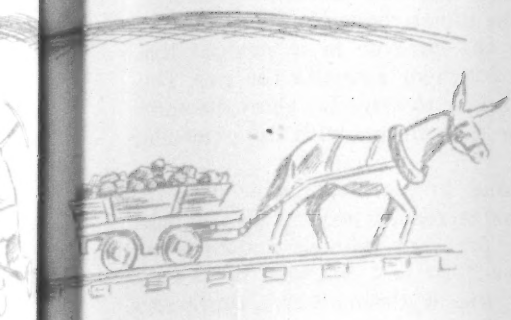


Fig. 3—Forward section of extensible belt conveyor receiving coal from the continuous miner. Additional idler sections, against the far wall, are added as the forward section moves to follow the miner. No bolting is required. Limberollers supporting the belt are pressure molded neoprene disks mounted on neoprene sheathed, braided, steel cable



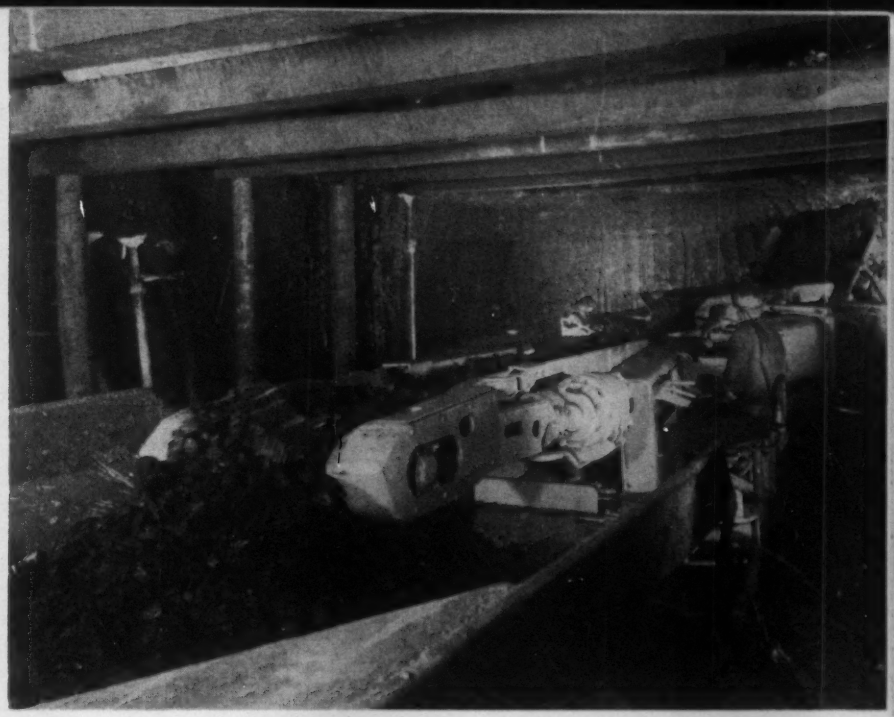


Fig. 2—Continuous miner pivots both horizontally and vertically at the head. All linear motions in the miner such as advancing, elevating, retracting, lowering, and swinging are hydraulically powered. Water is supplied to reduce dust

AUTOMATION ADVANCES

CONTINUOUS MINING OF COAL

COAL MINING is an industry that can serve to demonstrate automation potentials—reduction of operating costs, improvement in unpleasant and dangerous working conditions, increased and continuous output. By these achievements the competitive position of coal obviously becomes more favorable.

As is most often the case, automation in the mines has been a long, steady development dating back to the nineties when the first mechanical drilling and loading machines were introduced. One improvement led to another until the major problem was how to get coal out of the mine as fast as mining equipment produced it, *Fig.* 1. As continuous miners improved, transportation difficulties increased; it became evident that continuous mining was dependent upon service haulage.

The No. 3 mine of an Ohio mining company produces coal continuously with equipment designed and developed by the Joy Mfg. Co., *Fig.* 2. Latest addition to this equipment is an extensible belt conveyor, *Fig.* 3, used to follow coal digging machines and transport coal to the main conveyor. By automatically tensioned, multiple-loop storage, the extensible conveyor can follow a continuous miner for 50 feet without adding to the belt. Idlers known as Limberollers support the conveyor as its length increases to follow the miner.

Conveyor forward section has a swivelling, self-aligning tail pulley that extends the belt. Hydraulic tension and slippage controls are located in the back end, *Fig.* 4, and an automatic signal device at the miner-end of the conveyor indicates when belt storage has been exhausted. Head and tail

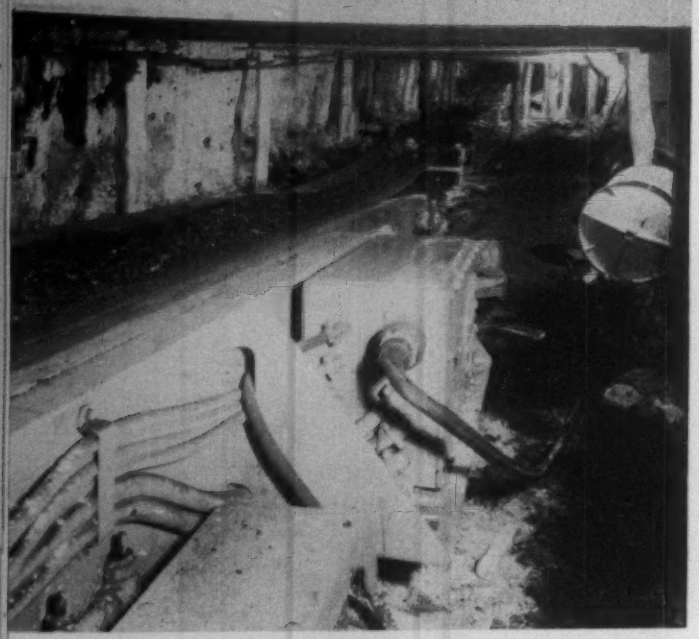


Fig. 4—Extensible belt conveyor at discharge end. Reel on the right contains 100 feet of belting which will provide 50 feet of additional conveyor

sections are mounted on hydraulically powered crawlers.

New sections of belt are added at the rear element of the conveyor with a power drive, *Fig.* 5, in slightly more than 5 minutes to extend the overall length an additional 50 feet each time the continuous miner has completed a 50-foot advance.

In order that the miner-conveyor unit may turn corners but keep the coveyor in a straight line, a pivoting bridge conveyor connects the two. This bridge allows the miner to drive for short distances in directions other than in-line with the extensible belt.

Continuous mining in the No. 3 mine with the extensible belt has increased production per shift approximately 20 per cent. Mining machines cut tunnels as long as 1000 feet followed by the extensible conveyor, *Fig.* 6. Production is continuous throughout the drive except for intervals when belting is added to extend another 50 feet.

As the illustrative photographs indicate, coal mining is still a difficult and arduous task. But no one can doubt that much progress has been made since the pick, shovel, and donkey cart.

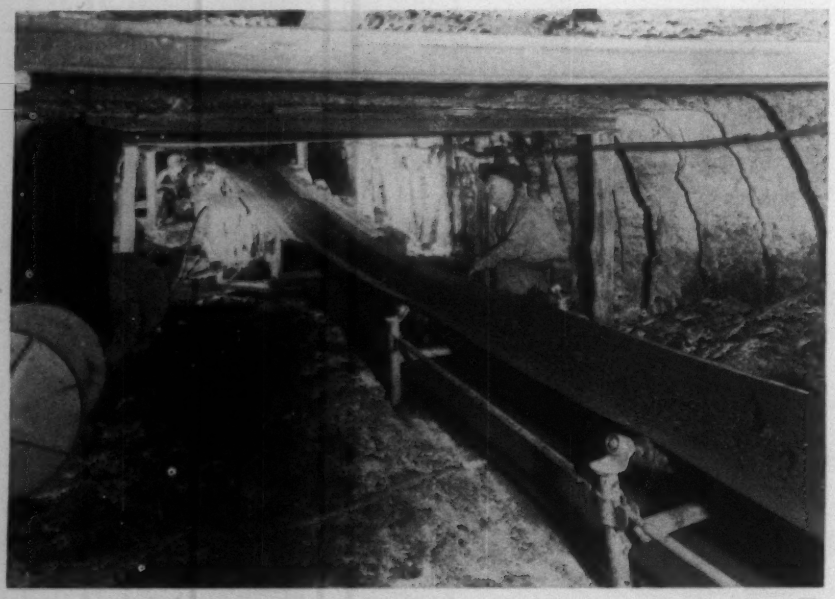


Fig. 5—Miners waiting to add a reel of belting to the conveyor. This end of the extensible conveyor remains stationary during a drive and contains belt tensioning, multiple loop storage and belt drive

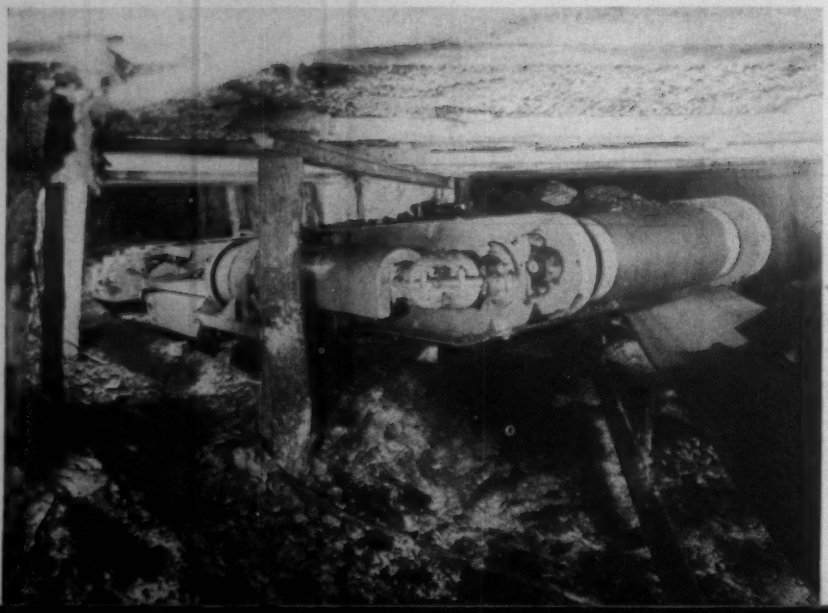


Fig. 6—End of the extensible belt conveyor feeds coal to the central, permanent conveyor. This room has been driven at a 60 degree angle to the central corridor and may be as long as 1000 feet. Conveyor drive motor, just behind timber post, must be explosion proof because of mine gases

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Part 5

HYDRAULIC AND PNEUMATIC SERVOS

ANALYSIS OF PUMP AND VALVE SERVOS

As an important control component of hydraulic servo systems, the slide valve is thoroughly studied in all its design and operating particulars

GENERAL SERVO theory, elements, and performance have been treated and flow conditions analyzed in previous articles of this series. Consideration should now be given to an analysis of elasticity effects in pump controlled servos and a discussion of linearity, loading, design and construction factors of slide valves.

Variable Displacement Pump Servo

In pump-controlled servos it is often impracticable to place the pump near the motor. Where distances are large the oil in the transmission pipes between the two may have appreciable elasticity. In addition, if the motor is of the cylinder type it will usually contain a still larger volume of oil, the elasticity of which must also be taken into account. In this case the elasticity is a maximum when the piston is near the end of its travel and the pump is delivering into a full cylinder space. The effective volume V in either case (cylinder or rotary motor) is therefore the full displacement volume of the cylinder plus the volume of oil in one pipe. The bulk modulus of the oil is designated as N and the cylinder area as A. In the case of a rotary motor and reduction gear, A is the effective area which generates the volume required to produce unit displacement at the low-speed end of the reduction gear.

Any change in the load pressure P_L will produce a corresponding compression of the oil, and if we take $P_L = 0$ as datum point the oil compression is $P_L V/N$, and the corresponding motor movement is $P_L V/AN$. The motor movement W is then given by $AW = \int Q_m\,dt - (P_L V/NA)$ or, if we write s for d/dt

$$AsW = Q_m - \frac{V}{NA}\,sP_L \qquad (24)$$

In the case of a rotary motor there is appreciable leakage in the motor. If Q_L is the flow from the pump and Q_m is the effective flow into the motor, the leakage is given by $Q_L - Q_m = R_m P_L$. Equa-

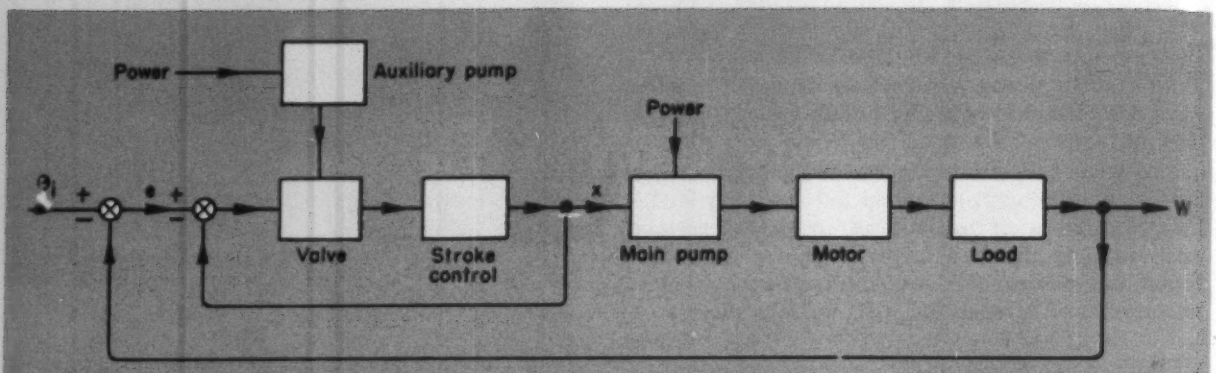


Fig. 60—Block diagram for a variable delivery pump servo with direct feedback from the motor output to the pump delivery control

tion 24 can therefore be written quite generally

$$As\,W = Q_L - R_m P_L - \frac{V}{N}\,s\,P_L \qquad (25)$$

with R_m zero in the case of a cylinder. Combining this with the basic pump formula (See Part 4—AUTOMATION, Jan. 1955, Equation 23), we obtain the characteristic for the pump-motor combination:

$$As\,W = Gx - RP_L - \frac{Vs}{N}\,P_L \qquad (26)$$

The complete servo analyzed will be that pictured in *Fig.* 56 (See Part 4), assuming direct feedback from the motor output to the pump delivery control. The block diagram for this servo is shown in *Fig.* 60.

Consider now the subsidiary loop formed by the preamplifier servo. This is a low power device in which compressibility effects can be neglected. The load on the preamplifier piston can be made low in comparison with the auxiliary pump pressure, and under these conditions the preamplifier can be treated as linear. The flow out of the valve is $g(e - x)/2$, where g is the "gain constant" of the valve, and if a is the area of the preamplifier piston the travel of the latter is $x = g(e - x)/2as$. The transfer function for the preamplifier loop is then

$$\frac{x}{e} = \frac{1}{1 + t_1 s} \qquad (27)$$

where $t_1 = 2a/g$.

Substituting in Equation 26

$$\frac{Ge}{1 + t_1 s} = As\,W + \left(R + \frac{Vs}{N}\right) P_L \qquad (28)$$

The load overcome by the motor is $P_L A$. This load will in the most general simple case consist of a mass M, a viscous damping factor f, and an elastic restraint factor h, in which case

$$P_L A = W(Ms^2 + fs + h) \qquad (29)$$

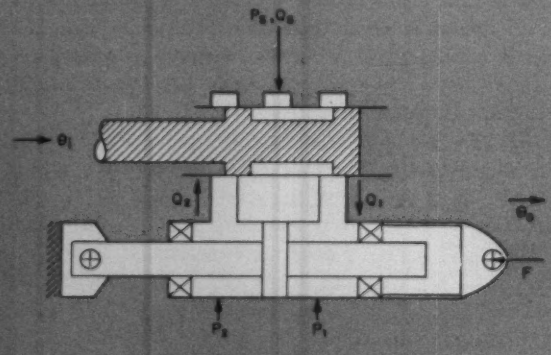


Fig. 61—Elementary valve-controlled servo arrangement

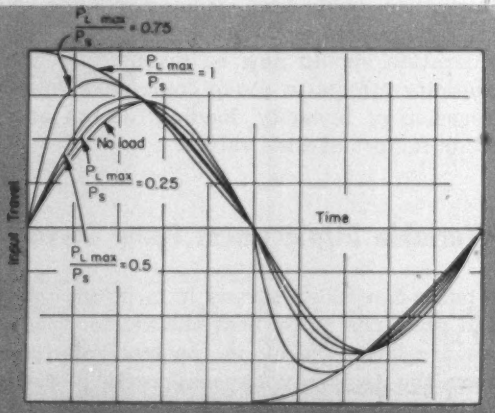


Fig. 62—Required input travel to produce harmonic output travel for elementary valve servo. Departure of the input travel curve from a pure sine wave is taken as a measure of the nonlinearity of the system

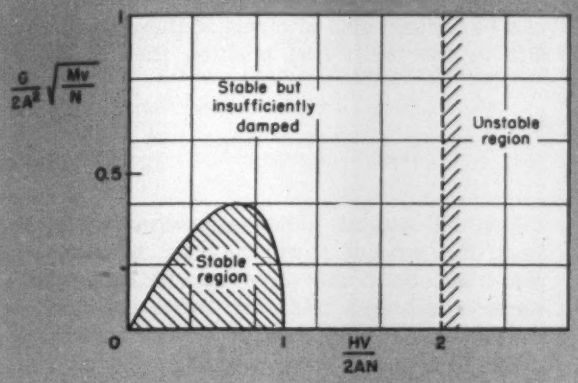


Fig. 63—Stability limits for elementary valve-controlled servo

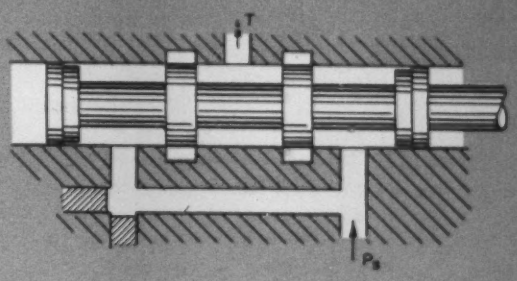


Fig. 64—Friction can be avoided by using stepped lands which provides an antifriction valve

Inserting this in Equation 28 gives the loop transfer function of the complete system:

$$\frac{W}{e} = \frac{G}{(1 + t_1 s)\left[\frac{VMs^3}{NA} + \left(\frac{RM}{A} + \frac{Vf}{NA}\right)s^2 + \left(\frac{Rf}{A} + \frac{Vh}{NA} + A\right)s + \frac{Rh}{A}\right]} \quad (30)$$

Experimental data, correlated with theory, for a servo of this type and the individual components, are quoted by Hannah.[14] A further reference is G. C. Newton.[13]

Nonlinearity Effects in Valve Servos

The fact that the characteristics of valves, as expressed for instance by Equations 10 to 14, are nonlinear makes the analysis of valve servos a matter of some difficulty. If the load pressure is quite small as compared with the supply pressure, Equation 10 for an ideal valve becomes linear and the characteristics are extremely simple. This implies of course that most of supply power is wasted, which is permissible in some low-power servos such as may be used in process control, instrument work or in preamplification stages, such as that just analyzed for the variable-delivery pump system. Where such conditions do not hold, more elaborate methods of analysis must be used.

Treatment will be restricted to the simplest type of valve servo discussed previously and shown again in *Fig.* 61. One useful approach to the problem is that made by Coombes[6b] who has considered a servo of this type with an ideal valve, the load being pure inertia and compressibility effects being neglected. Under these conditions it is possible to work out the input travel required to give a sinusoidal travel at the output for various ratios of P_{Lmax}/P_s. Coombes's curves are shown in *Fig.* 62. The departure of the input travel curve from a pure sine wave is taken as a measure of the nonlinearity of the system. It is seen that the nonlinearity is quite small if P_{Lmax}/P_s does not exceed 0.5, and it has been suggested that this is a desirable upper limit. Many servos, however, allow higher ratios for the sake of power economy.

Another approach is that made by Gold, Otto and Ransom[16] who consider exactly the same system as Coombes. By some very ingenious approximations, response curves are derived for a displacement step function input, also amplitude response curves for a sinusoidal input at various frequencies. The calculated curves are checked against experiment, with which they show good agreement. In common with all nonlinear systems, the response for all types of input varies with the input amplitude. An interesting point brought out by the analysis is that with a step function input the pressure in the return line can exceed the supply pressure during the deceleration stage.

A third method of approach[7b] is to consider the behavior of the system for small perturbations from some steady-state condition. Any nonlinear system approximates to linearity if the perturbations are sufficiently small. This method has the great advantage that the important effect of oil compressibility can be taken into account. Unlike the method of Gold, Otto and Ransom, it gives little information on the response to large amplitude step function or harmonic inputs, but it does give an assessment of the degree of stability of the servo, which is usually the most important result sought in analysis. This method will therefore be given in detail.

Analysis of Simple Valve Servo

The system considered will be that of *Fig.* 61, but the valve may or may not have some underlap,

[14]References are tabulated at end of article.

and may also have a shunt across it. If compressibility is allowed for, the flows in and out of the cylinder may no longer be assumed equal and will be denoted by Q_1 and Q_2 respectively. Pressures on the corresponding sides will be denoted by P_1 and P_2 where $P_1 - P_2 = P_L$. The volumes on the two sides will be denoted by V_1 and V_2. In valve servos the valve can most often be located very close to the motor, and the volume in the piping or passages between valve and motor may therefore be neglected. V_1 and V_2 are then volumes for the motor only, and will be negligible if the motor is of the continuous rotary type. If the motor is a cylinder $V_1 + V_2 = V$, where V is the total cylinder stroke volume. Equation 24 can now be modified to give

$$As\,W = Q_1 - \frac{V_1}{N}\,sP_1 = Q_2 + \frac{V_2}{N}\,sP_2$$

which gives

$$As\,W = \frac{Q_1 V_2 + Q_2 V_1}{V} - \frac{V_1 V_2}{NV}\,sP_L \qquad (31)$$

This may be integrated with respect to time, giving

$$AW = \frac{1}{V}\int (Q_1 V_2 + Q_2 V_1)\,dt - \frac{1}{NV}\int V_1 V_2\,dP_L$$

Consider the effect of a sudden change in load, causing a sudden change in P_L. The first term on the right-hand side will then disappear, and if W and P_L now denote changes in cylinder travel and load pressure, the relation (since V_1 and V_2 can now be regarded as constants) is

$$AW = -\frac{V_1 V_2}{NV}\,P_L$$

which is a maximum when $V_1 = V_2 = V/2$, or when the cylinder is at mid-travel. This tends to show that the mid-travel position gives the worst compressibility effects, and further analysis will be confined to that position only.

Now, let w, q and p be small perturbations in motor travel, flow and pressure respectively, with suffixes as for the main variables. Equation 31 can be written also in terms of these perturbations, and in the mid-travel position then becomes

$$Asw = \frac{(q_1 + q_2)}{2} - \frac{\frac{sp_L}{4}}{N}\,V$$

For the sake of consistency with previous analyses, the symbol e will be used to denote small perturbations in the valve travel x. Then we may write

$$q_1 = \frac{\partial Q_1}{\partial x}\,e + \frac{\partial Q_1}{\partial P_1}\,p_1 + \frac{\partial Q_1}{\partial P_s}\,p_s \qquad (33)$$

$$q_2 = \frac{\partial Q_2}{\partial x}\,e + \frac{\partial Q_2}{\partial P_2}\,p_2 \qquad (34)$$

The term in P_s represents the effect of any nonconstancy in supply pressure, which as shown in *Fig.* 30 (See Part 3—AUTOMATION, Dec. 1954) may be appreciable even with nominally "constant-pressure" systems. $\partial Q_1/\partial P_s$ is always negative, and it can be shown that this has a favorable effect on stability, but insufficient to stabilize an otherwise unstable system. Furthermore, unless the pressure regulating device is very close to the valve, this effect may be lost due to various time lags. It is therefore best to neglect the term $\partial Q_1/\partial P_s$ altogether.

Now the partial derivatives are expressed in terms of steady-state quantities, to which symmetry conditions apply, and hence

$$Q_1 = Q_2 = Q_m\,;\; P_1 = \frac{P_s + P_L}{2}\,;\; P_2 = \frac{P_s - P_L}{2}$$

Hence $$\frac{\partial Q_1}{\partial x} = \frac{\partial Q_2}{\partial x} = \frac{\partial Q_m}{\partial x} = G$$

and $$\frac{\partial Q_1}{\partial P_1} = -\frac{\partial Q_2}{\partial P_2} = 2\,\frac{\partial Q_m}{\partial P_L} - 2\,R$$

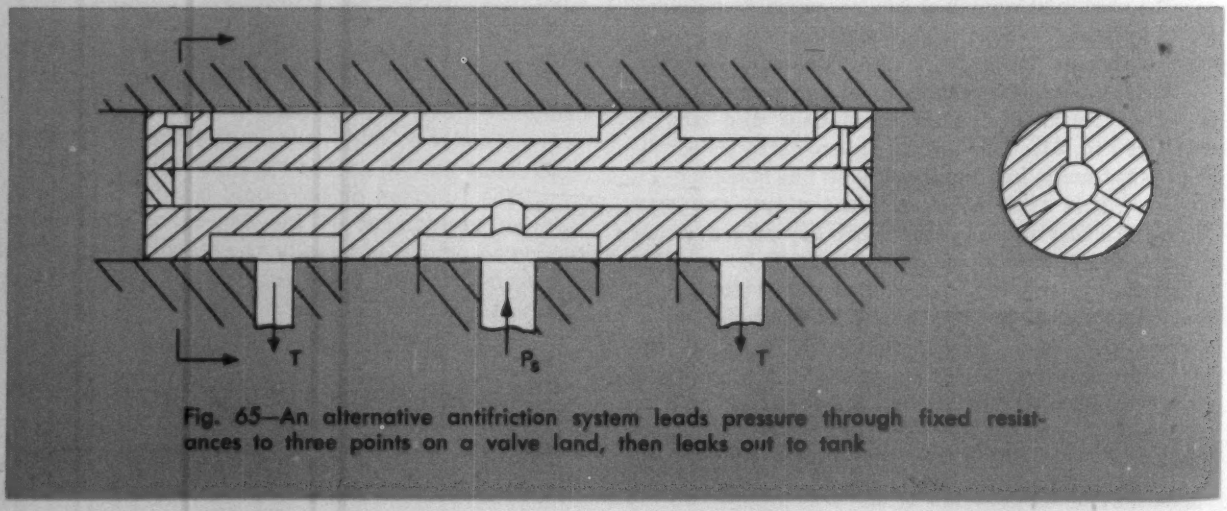


Fig. 65—An alternative antifriction system leads pressure through fixed resistances to three points on a valve land, then leaks out to tank

where the parameters G and R are those calculated in the foregoing general discussion on valve characteristics.

Equations 33 and 34 then become $q_1 = Ge - 2Rp_1$ and $q_2 = Ge + 2Rp_2$. Inserting these expressions in Equation 32, we get, with $p_L = p_1 - p_2$

$$Asw = Ge - Rp_L - \frac{sp_L}{4N} V \qquad (35)$$

which is the counterpart of Equation 28 for the variable-delivery pump servo. The same type of load will again be assumed, which will also apply to perturbation terms, in which case Equation 29 can be written $P_L A - w(Ms^2 + fs + h)$. Inserting this in Equation 35 gives the loop transfer function of the servo for small perturbations

$$Y(s) = \frac{w}{e} = \frac{G}{\frac{MVs^3}{4NA} + \left(\frac{RM}{A} + \frac{Vf}{4NA}\right)s^2 + \left(\frac{Rf}{A} + \frac{Vh}{4NA} + A\right)s + \frac{Rh}{A}} \qquad (36)$$

which is very similar to Equation 30 for the variable-delivery pump servo, without the extra time lag term due to the preamplifier.

In this case it is possible to derive conditions for absolute stability by applying the Routh criterion to the characteristic equation $1 + Y(u) = 0$. In the case of a cubic $a_0u^3 + a_1u^2 + a_2u + a_3 = 0$ the Routh criterion is $a_0a_3 < a_1a_2$ to give stable roots—roots with a negative real part. It is easily shown that the most adverse case is when the load is pure inertia, in which case both f and h are zero. The criterion then becomes

$$\frac{G}{R} < \frac{4NA}{V} \qquad (37)$$

This is a condition for absolute stability—having the absence of divergent oscillations. The required degree of damping may be specified as usual by setting an upper limit for the system amplitude gain M. This has been investigated by Harpur[7b] who states that the usual criterion of $M < 1.4$ involves excessively complicated analytical expressions, but that a simple solution is obtainable if the criterion is taken instead at the slightly over-pessimistic figure of $M < 1$. To meet this condition, Harpur shows that the limiting case is given by

$$b^3 - 4abc + 8a^2 = 0 \qquad (38)$$

where $a = \frac{VM}{4NAG}$; $b = \frac{MR}{AG}$; $c = \frac{A}{G}$

Put $G/R = H$. As shown previously,

$$H = \frac{\partial P_L}{\partial x} \text{ where } Q_L \text{ is a constant}$$

and measures the output stiffness of the servo. Equation 38 can then be written

$$G^2 \frac{MV}{4A^4N} = \left(\frac{V}{2AN} H\right)^2 \left(1 - \frac{V}{2AN} H\right) \qquad (39)$$

while the conditions for absolute stability Equation 37, is

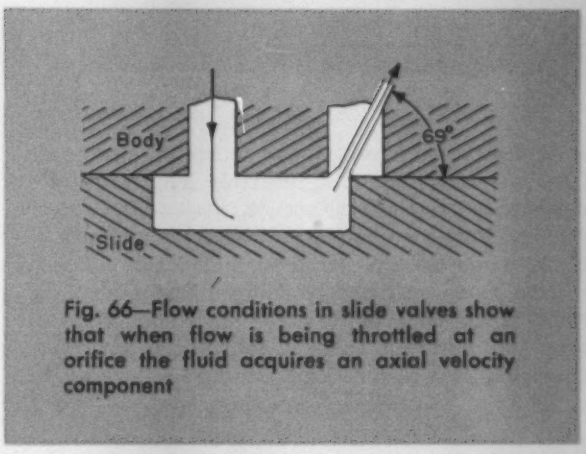


Fig. 66—Flow conditions in slide valves show that when flow is being throttled at an orifice the fluid acquires an axial velocity component

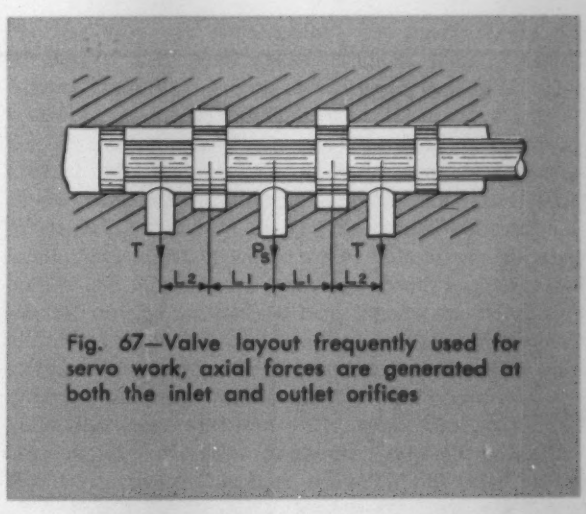


Fig. 67—Valve layout frequently used for servo work, axial forces are generated at both the inlet and outlet orifices

$$\frac{V}{2AN} H < 2$$

These two results are plotted in *Fig.* 63, which shows the values of the parameters required for absolute stability and for sufficient damping.

For an ideal valve used without shunt, Equation 17 shows that R is zero when the valve is central, and hence H is infinite. A servo with this type of valve is therefore unstable in the immediate neighborhood of zero error signal, though it may well become stable when moving beyond a certain speed. With a shunt, as may be seen from Equations 18 and 19, the servo may be stabilized under all conditions.

With an orifice shunt, however, R becomes infinite and therefore H zero at zero output load. The servo is then stable but insufficiently damped. Thus, a shunt having pure orifice characteristics

is undesirable. A satisfactory compromise in the form of an orifice of appreciable length, giving a measure of viscous resistance, may well be satisfactory. Pure viscous resistances are sometimes difficult to devise. A servo with underlapped valve can be made sufficiently damped under all conditions, if the underlap is made large enough. With underlap, however, there is substantial power consumption even at zero load, and an ideal valve with shunt may be preferable on this score.

Fig. 63 shows that the valve gain factor G is limited to a maximum value, which occurs when $H = 4AN/3V$ which is therefore the optimum value of the stiffness parameter H. The maximum value of G is given by

$$G_{max} = \frac{4}{3\sqrt{3}} A^2 \sqrt{\frac{N}{MV}} \qquad (40)$$

With pure inertia load, i.e. with f and h both zero, the loop transfer function, Equation 36, becomes

$$\frac{w}{e} = \frac{\frac{G}{A}}{s\left(\frac{MVs^2}{4NA^2} + \frac{RMs}{A^2} + 1\right)}$$

and G/A is therefore the loop gain factor or velocity error coefficient of the servo, which is a direct measure of its accuracy. Thus, the maximum allowable loop gain factor when H has its optimum value of $4AN/3V$, is

$$K_{max} = \frac{4}{3\sqrt{3}} A \sqrt{\frac{N}{MV}} \qquad (41)$$

The dimensions of K are sec^{-1}, or in./sec velocity per inch of valve travel (or error). If A and V are in inch units, N in psi, mass M must be: pounds divided by 32.2×12.

This is quite a severe limitation in the case of high-power servos using a cylinder as motor, when

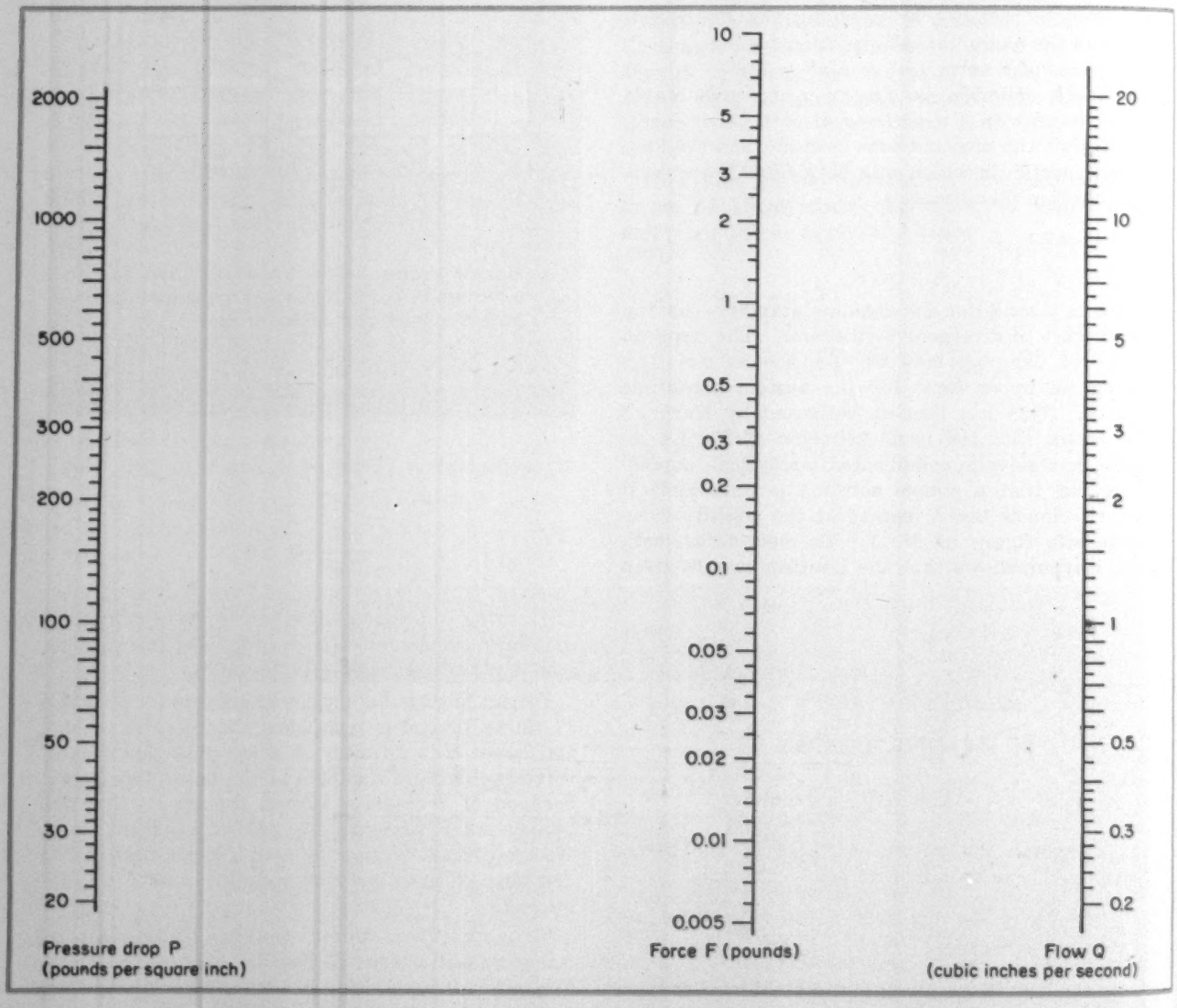


Fig. 68—Nomogram for hydrodynamic forces on perfectly symmetrical ideal slide valve

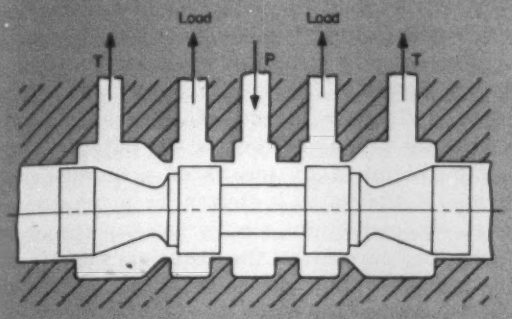


Fig. 69—Basic design of valve in which steady-sate hydrodynamic forces are balanced

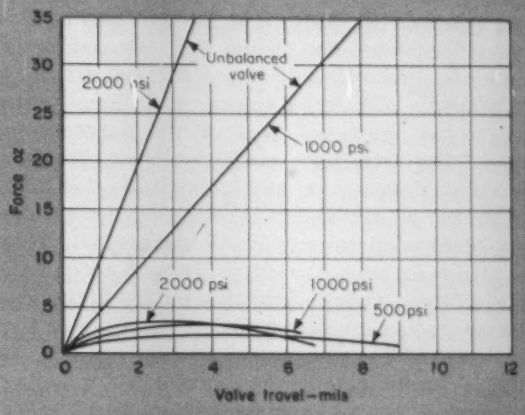


Fig. 70—Charasteristics of balanced valve shown in *Fig.* 69

the load is predominantly due to inertia, which is often the case. In many cases, the limitation is overcome by using rotary motors with reduction gearing, thus decreasing V. Much improvement can also be obtained from the use of phase advance, a practical means of achieving this will be discussed later. The limitation on gain is usually not a serious matter in marine or vehicle steering or aircraft flying controls, where large errors may be allowable. In the case of pump-controlled servos, the limitations are of a similar order. Indeed the position is somewhat worse, as the effective volume is higher, there is an additional time lag due to the preamplifier. The stiffness factor R depends on the volumetric efficiency of the pump, and may be too low, giving a value of H below the optimum.

Conway and Collinson [7a] quote some experimental frequency response curves which agree quite closely with results calculated by the method of analysis given in this section.

Operating Loads on Slide Valves

The action of the vast majority of fluid pressure servos depends in the first instance on a determined travel, usually the error signal or some simple function thereof, being applied to a valve. This is true even of pump-controlled servos, which almost invariably have a preamplifier of the valve-controlled type. Accurate travel can be obtained only if the available force is large as compared with the forces required to operate the valve, especially if the latter include frictional components. In those servos where the signal is derived from a gyroscope or other sensitive instrument and/or applied through a synchro device or transducer, the force available is most often extremely low. Hence a knowledge of the operating forces on valves is of great importance in servo work. The force on a seating valve is immediately obtainable from the pressures and seat areas, and is usually much higher than that required to operate a slide valve handling a comparable power. Hence a study of the somewhat complex forces on slide valves is of special importance. These forces consist of frictional and hydrodynamic components, the latter often being referred to as "Bernouilli forces".

At first sight it would seem that if the obvious conditions of symmetry are observed, a slide valve should not be subject to any transverse force and should therefore be frictionless. It has been known for a long time, however, that quite substantial friction forces do in fact occur if the valve has been stationary for some time, although they disappear again as soon as movement begins. Much knowledge has been gained about these forces as a result of recent research by Sweeney[15] and Blackburn[12].

Clearances in slide valves are extremely low, perhaps 0.0003-inch on diameter or even less, and with any commercially practicable manufacturing methods the inevitable imperfections such as taper, ovality, and lack of straightness of center line, are of comparable magnitude. Due to these imperfections, the pressure distribution in the leakage paths formed by the clearances between slide and body will depart quite substantially from the ideal symmetrical pattern, and transverse forces will be set up which disappear during movement due to the onset of hydrodynamic lubrication. These forces cause friction to be developed—they may be aggravated by particles of fine dirt which tend to lodge themselves at the entrance to the leakage path on the higher pressure side, and which cast "shadows" of low pressure.

It can be shown that if the mating surfaces have a taper in such a direction that the gap decreases in the direction of leakage flow, any eccentricity between slide and body will cause a centralizing transverse force, and friction will not occur. Con-

versely, if the taper is in the opposite direction, the force is a decentralizing one, the slide will be pressed against the body, and friction will be developed. Blackburn has shown that the maximum force due to this effect is about $0.27pA$, where p is the pressure difference across the leakage path, and A is the projected area of the surfaces in contact. The effective coefficients of friction measured by Sweeney are as high as 0.25 (this high figure is due to a measure of wedging action, occurring because of the very small clearance). This would give a maximum friction force of about 0.07 pS. This figure, though probably on the high side, is perhaps good enough for design purposes in the present state of knowledge.

Friction forces can be kept down by reducing the amount of contact surface subject to pressure gradient, particularly in the central position, since the valve may never in practice stay quite still in any other position. In some valves with negative lap this area may even be zero. In other cases various methods may be used to avoid the onset of friction. The most widely used method is "dither"—continuous high-frequency oscillations superimposed upon the input signal. The frequency of the dither should be well above the cut-off frequency of the servo, in order to avoid dithering the output. Dither may be obtained by means of a motor-driven eccentric. If the valve is driven by a transducer, dither is obtained quite simply by superimposing an alternating current on the electrical signal. An equally effective but not always so convenient method is to rotate the valve sleeve.

Friction can also be avoided by providing deliberate taper on the valve in the required direction; the optimum amount of taper is a reduction in diameter about equal to the diametral clearance, but this may be too small for practicable manufacture. About five times the clearance is a good upper limit, and still quite effective. A somewhat easier manufacturing proposition is to replace the taper by a step, which is also quite effective. One suitable arrangement of valve embodying this feature is shown in *Fig.* 64. Another system is shown in *Fig.* 65. Pressure is led through fixed resistances to three points on a valve land, whence it leaks out to tank. The fixed resistances and the clearance in the leakage path form a potentiometer. The effect of which is to alter the pressure in the leakage paths according to the amount and direction of eccentricity of the valve, resulting in strong self-centralizing action.

In some servos it is found in practice that friction forces do not develop, either because of vibration from some outside source, or because the valve is never quite still in operation.

Hydrodynamic forces have been investigated by Lee and Blackburn[10], who have shown that they consist of a steady-state component depending on valve opening and tending to centralize the valve, and a transient component depending on the rate of opening which may result in positive or negative damping.

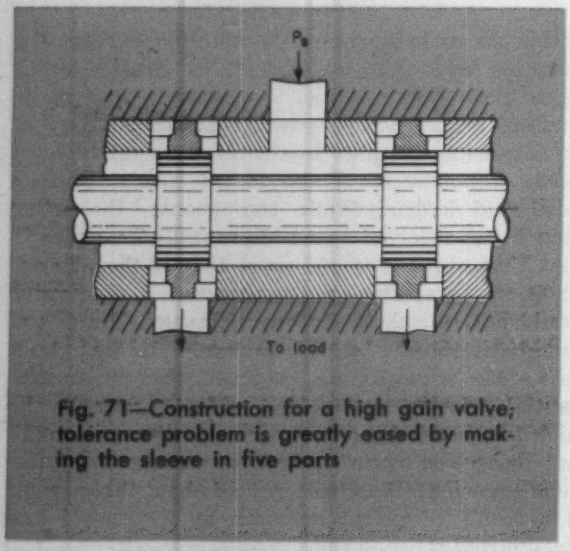


Fig. 71—Construction for a high gain valve; tolerance problem is greatly eased by making the sleeve in five parts

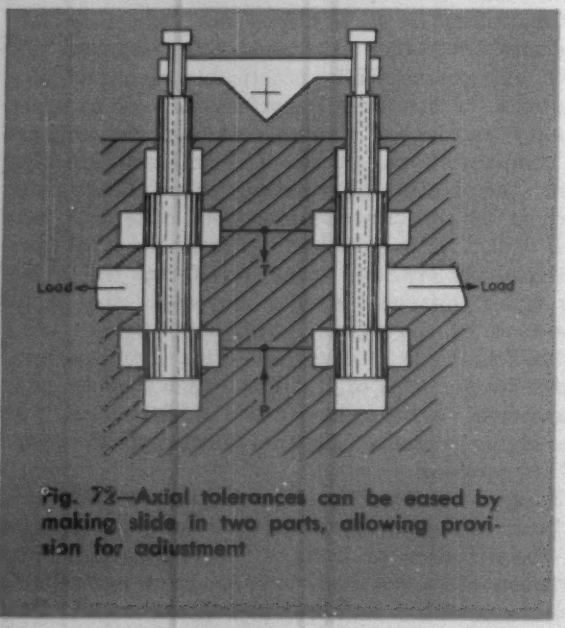
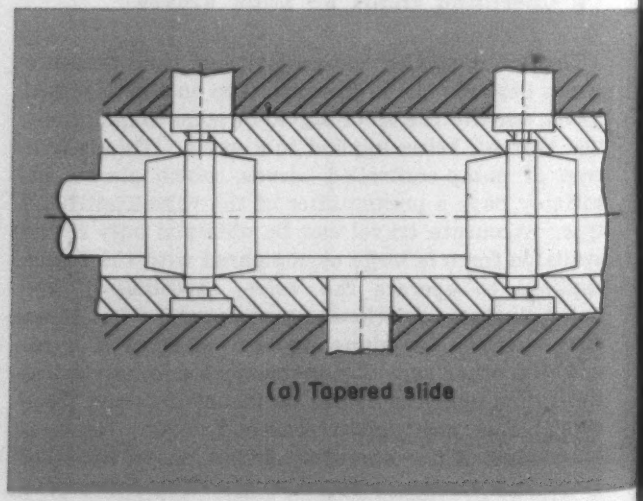


Fig. 72—Axial tolerances can be eased by making slide in two parts, allowing provision for adjustment



(a) Tapered slide

The steady-state component is by far the more important, and is due to the fact that when the flow is being throttled at an orifice the fluid acquires an axial component of velocity, as shown in *Fig.* 66. If the land on the slide is perpendicular, the angle between the flow and the axis is about 69 degrees, as shown. With a valve of the type of *Fig.* 67, which is a layout frequently used for servo work, forces are generated both at the inlet and outlet orifices. Under these conditions, with a perfectly symmetrical ideal valve the steady-state centering force is given by

$$F = 0.0064\ Q\ \sqrt{P} \qquad (42)$$

where Q is the flow, assumed equal as between inlet and outlet orifices, and P is the total pressure drop, including the sum of the drops at inlet and outlet. If Q is in cubic inches per second and P is in psi, Equation 42 gives Q in lb. Making use of Equation 7 for the relationship between flow and pressure drop gives the alternative formulations

$$F = 7.2\ (10^{-5})\ \frac{Q^2}{A} = 0.57\ AP$$

where A is the area at either orifice, in square inches.

From these relationships it is possible to derive expressions for the power gain obtainable from a valve, which is measured by the quantity

$$g = \frac{U}{\frac{Fx}{2}}$$

where U is the power delivered to the load and x the valve travel, $Fx/2$ being the work required to operate the valve. For a given supply pressure the power transmitted is a maximum when $P_L = 2P_s/3$. The maximum gain is obtainable if the area increases as rapidly as possible with valve opening, which is the case when the ports are in the form of full grooves. The orifice area is then $A = \pi Dx$, where D is the valve diameter. Under these conditions it is easily shown that the maximum gain is proportional to DP_s^2/U. The above expression of course applies only if the significant loads are those due to hydrodynamic forces. It shows that the gain obtainable increases rapidly with pressure, and decreases with the power handled. For low powers, however, a valve designed for maximum gain would involve excessively close axial tolerances, especially if the pressure is high.

Lee and Blackburn[10] have also developed a type of valve in which steady-state hydrodynamic forces are balanced, and the basic design of which is shown in *Fig.* 69. The effect is obtained by a specially shaped slide, which causes a negative or decentralizing force to be developed at the outlet orifice, which balances the force developed at the inlet orifice. The characteristics of a valve of this type are shown in *Fig.* 70.

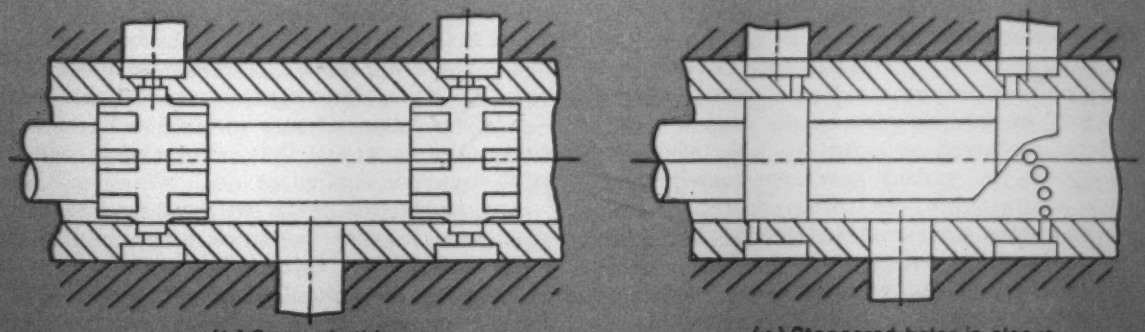
Transient hydrodynamic forces are proportional to the rate of opening of the valve, and may be regarded as unimportant provided they do not amount to negative damping, which would cause oscillations. With the type of valve of *Fig.* 67, negative damping is avoided if $L_1 > L_2$.

▶ Slide Valves for Servo Purposes

The slide valves used in servo work tend to be rather different from those used in ordinary hydraulic equipment, and a few remarks on their construction are therefore appropriate.

The usual materials are hardened steel for both slide and sleeve, the latter usually being a liner in the body. If the valve is designed for high gain, axial tolerances are quite small, and grooves formed directly within the sleeve may lead to manufacturing difficulties. Furthermore if the valve has negative (or even nominally zero) lap, provision must be made to prevent the lands from catching in the grooves. With the construction of *Fig.* 67 this can be done by giving the outer lands a slightly reduced clearance.

The tolerance problem is greatly eased by making the sleeve in five parts, as shown in *Fig.* 71. The liners are accurately ground to length, pressed



(b) Grooved slide (c) Staggered holes in sleeve

Fig. 73—Types of low gain valves using one-piece sleeves

into the body, and finished afterwards. The problem of axial tolerances can be eased still further, though at the cost of constructional complication, by making a two-part slide with provision for adjustment, as shown in *Fig.* 72. The number of tolerance lengths is then reduced from five on one component to one on each of two components, for both slide and sleeve. Complete elimination of lengthwise tolerances is possible by taking this a stage further, and splitting the slide into four parts, with adjustment on each.

In many servos a severe limit is set on valve gain by stability considerations, as foregoing analyses have shown. The "gain" concerned here is not the power gain, but the flow out of the valve per unit error. This gain can always be reduced by decreasing the valve travel per unit error, simply by operating the valve through a suitable movement-reducing lever or its equivalent. This has the advantage of keeping to a minimum the work required to operate the valve, but the disadvantage that axial tolerance problems are as severe as ever, the backlash must be closely watched. In many cases, particularly if ample operating loads are available, it is therefore preferable to use a valve having an inherently low gain. With the design shown in *Fig.* 71, gain can be reduced simply by reducing the total width of the slots in the sleeve opposite the valve lands. Other forms of low gain valve, using one-piece sleeves, are shown in *Fig.* 73. That shown at *A* has tapered slide lands, that at *B* tapered grooves in the slide, and that at *C* a series of staggered holes in the sleeve. The first two may be rather sensitive to jamming by particles of coarse dirt. The third has a nonlinear relationship between travel and orifice area, but a fair approximation to linearity is obtainable by suitable spacing of the holes.

▶ Forces on Variable Delivery Pumps

When a variable delivery pump is used as an amplifying device, a knowledge of the forces required to operate the delivery control is obviously necessary in order to decide whether preamplification of force is necessary, and, if it is, to provide data for designing the preamplifier stage.

These forces depend on the type of pump, and on various small details of design. Even in the simplest pumps the effects are of a highly complex nature. For these reasons no attempt will be made to give further particulars here, but the reader may be referred to papers by Beacham[7e] and Palmer[8], who have analyzed the effects in question in some detail.

Final article of this series (Part 6), to cover complex servos, will appear in the March issue of AUTOMATION.

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POTENTIALS of automation are enormous. There are limitless numbers of industrial processes which can be automated, in addition to the many existing automatic processes which can be made more so.

Among the most important features of a properly planned and efficiently operated automatic factory are not only such benefits as lower costs and higher production rates but far greater stability in product quality and increased flexibility. You will note I said "properly planned and operated", since an automatic factory is only as good as the human brains which conceived and run it. No electronic computer, no matter how marvelously intricate and precise, can think; it can do only what human brains want it to do. The automatic factory, therefore, will not be a panacea for production ills, but will make even more effective an already effective organization.

It is also important to bear in mind that automation does not necessarily mean an entire plant, since only a portion of a given plant may be automatic. The significant factor is—what aspects of the overall operation can be and should be automated? If one restricts his thinking to an entire automatic plant operating virtually without human hands, he will greatly delay putting automation to work.

In addition to many benefits derived from automation in itself, equipping such plants will be an extremely large business. In fact, we envision the commercial electronics business expanding to a volume four times its present level —a billion-dollar industry within 6 or 7 years—substantial portion of that volume being industrial electronic equipment.

Any production levels we have had in the past, and many of industry's production concepts as we know them today, will fade into oblivion as automation comes increasingly into being, especially in our mass production industries.—*Don G. Mitchell, chairman of the board, Sylvania Electric Products Co.*

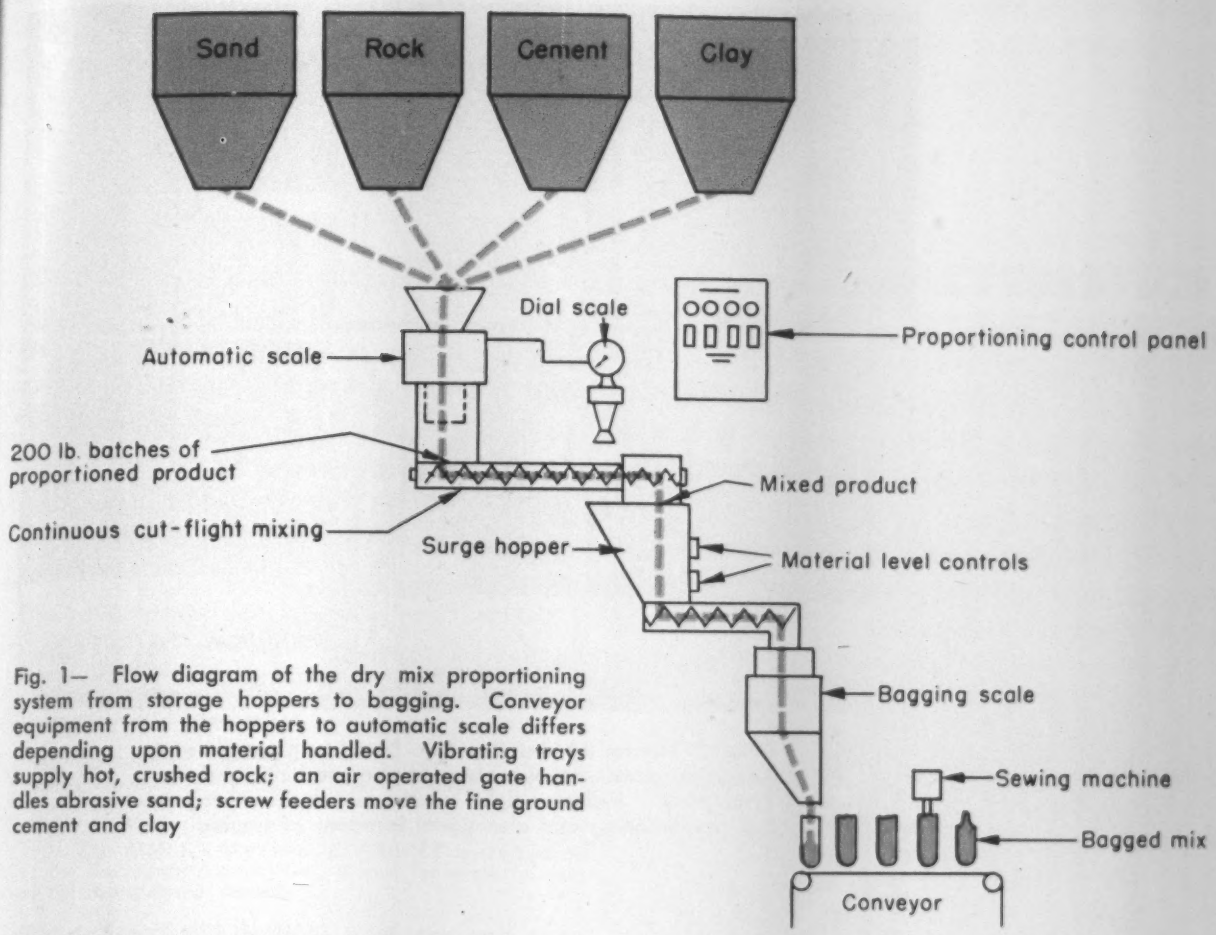


Fig. 1— Flow diagram of the dry mix proportioning system from storage hoppers to bagging. Conveyor equipment from the hoppers to automatic scale differs depending upon material handled. Vibrating trays supply hot, crushed rock; an air operated gate handles abrasive sand; screw feeders move the fine ground cement and clay

AUTOMATIC
BULK PROPORTIONING
IMPROVED BY BATCH WEIGHING

QUALITY CONTROL is particularly important in dry mix proportioning. Often there is no indication of proportioning quality until the mix is put to use, creating satisfied or dissatisfied customers. Inspection must be built into the process with accurate and flexible measuring control.

A remote-controlled weighing system for making proportioned mixes of cement products at Dry Mix Products Co. has replaced a volumetric proportioning system, *Fig.* 1. The company has gained accurate operation and has provided for quick and easy formula changing with a single operator.

Automatically proportioned products are premixed concrete, mortar, grout and sand-clay mixes. Designed by Richardson Scale Co., the remote weight-controlled proportioning system has cut mixing costs by permitting the company to proportion more product with less labor. In Select-O-Weigh batch proportioning, one automatic scale proportions all mixes by cumulatively weighing four individual ingredients needed to make up the premixed products.

Working at a panel that controls the entire proportioning operation, an operator can produce 15 tons per hour of mixed product. The automatic scale is set remotely to deliver a 200-pound batch every 24 seconds to a mixing conveyor. Batches of proportioned product are continuously being dis-

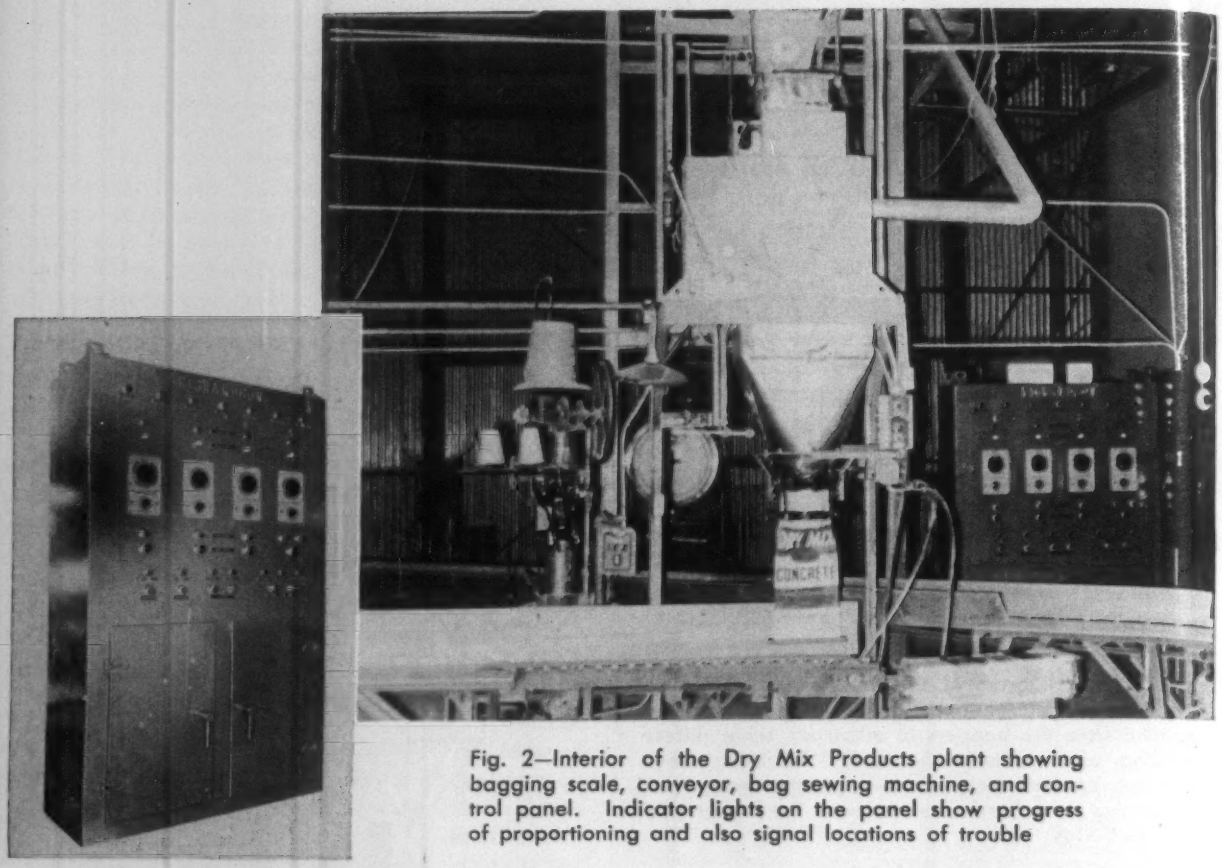


Fig. 2—Interior of the Dry Mix Products plant showing bagging scale, conveyor, bag sewing machine, and control panel. Indicator lights on the panel show progress of proportioning and also signal locations of trouble

charged from this conveyor; proportioning is done in relatively small batches to permit use of a continuous mixing conveyor and to eliminate the possibility of segregation.

Dry mix was previously proportioned with a continuous volumetric system in which vibrating feeders delivered material to a standard screw conveyor which mixed and transported material to the bagging scale. The company found that all materials fed uniformly except sand which increased in flow as the head of material in the bin was reduced and consequently, the increase had to be offset during bagging. Although a fairly uniform product was produced, all mixes were "heavy" in cement to provide a safety factor.

The volumetric system was also time consuming. Quick change-over with central, remote weight-control reduces overall production costs and permits more flexible operation. Proportion changes can be made in the time it takes an operator to turn a few dials. Formula changes are made two or three times a day, depending upon orders received and the status of warehouse inventory. Batching scales are accurate within 0.1 per cent.

Components of the new installation, *Fig.* 1, are four 30-ton steel bins (clay, sand, crushed rock and cement); conveyors running from bins to scale; an electronically controlled, dust tight, automatic weighing unit; a scale dial; continuous mixing conveyor; surge hopper; high-speed bagging scale; and a conveyor running from the surge hopper to the bagging scale. Flow is from bins to scale to mixer to surge hopper to bagging unit, *Fig.* 2.

Beside pilot lights and buttons, the control panel is equipped with four vernier dials—one for each ingredient—to select proportions for a given formula. When the proper quantity of an ingredient has been delivered to the weigh hopper on the scale, flow of that ingredient is automatically interrupted.

Raw materials used are brought to the plant by truck. Sand and crushed rock must be dried to remove surface and absorbed moisture before passing to indoor storage. A 30-inch diameter, 25-foot long rotary dryer is used and is heated by natural gas because other fuels would tend to give the material an undesirable oily coating. From the dryer, the material is discharged by bucket elevator into any of the four steel storage bins inside the plant.

Cement and clay do not require drying, and are brought to the plant in bulk, dumped into the outdoor hopper, and then transported by screw conveyor and bucket elevator into their respective bins.

Other types of mixes besides the concrete, mortar, grout and sand-clay mixes include such items as plaster, stucco and soil conditioners. Changes in weight proportions could be automatic since the proportioning system is equipped to be controlled by punched cards or templets. However, the operation is neither large nor complex enough to warrant it, at present.

Seventh of a series, AUTOMATION presents another section of the ASME standard "Automatic Control Terminology"; an original work of the Terminology Committee of the Industrial Instruments and Regulators Division. It is hoped these data sheets will assist in furthering the adoption of a standardized language in the field of automatic control

CONTROLLER ELEMENTS AND CHARACTERISTICS

701. The MEASURING MEANS consists of those elements of an automatic controller which are involved in ascertaining and communicating to the controlling means the value of the controlled variable.

701a. The PRIMARY ELEMENT is that portion of the measuring means which first either utilizes or transforms energy from the controlled medium to produce an effect which is a function of change in the value of the controlled variable.

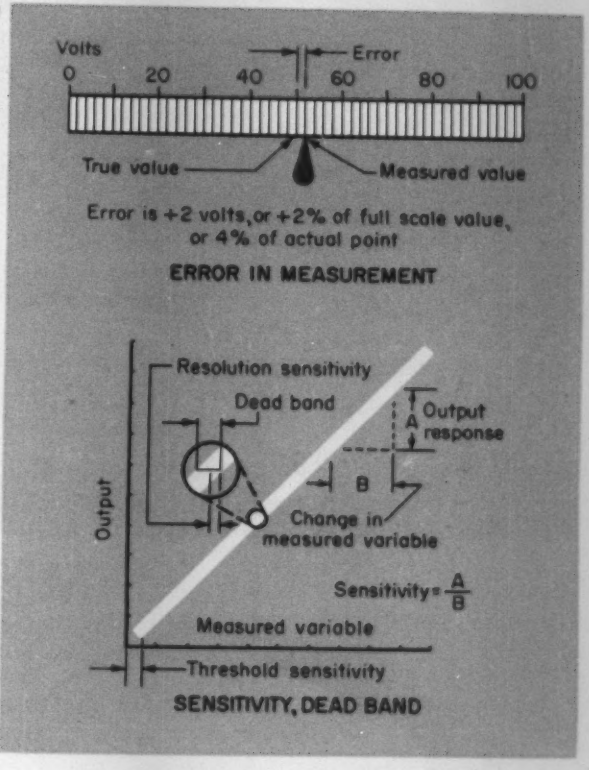
The effect produced by the primary element may be a change of pressure, force, position, electrical potential, or resistance.

702. The CONTROLLING MEANS consists of those elements of an automatic controller which are involved in producing a corrective action.

702a. A MOTOR OPERATOR is a portion of the controlling means which applies power for operating the final control element.

702b. The FINAL CONTROL ELEMENT is that portion of the controlling means which directly changes the value of the manipulated variable.

703. A SERVOMECHANISM is an automatic control system in which the controlled variable is mechanical position



BASIC TERMS

801. ACCURACY IN MEASUREMENT is the degree of correctness with which a measuring means yields the "true" value of a measured quantity.

The "true" value refers to accepted engineering standards, such as the standard meter, gram, etc. It is assumed that a true value always exists even though it may be impossible to determine.

802. PRECISION IN MEASUREMENT is the degree of reproducibility among several independent measurements of the same true value under specified conditions.

It is usually expressed in terms of deviation in measurement (see 804).

803. ERROR IN MEASUREMENT is the algebraic difference between a value which results from measurement and the corresponding true value.

A positive error denotes that the measured value is algebraically greater than the true value. Error is usually expressed in the units of the measured quantity, or as a fraction (or per cent) of the full scale value, or of the actual value.

804. DEVIATION IN MEASUREMENT is a statistical number representing the randomness among independent measurements of the same true value.

Deviation is variously expressed as: (a) the difference between any measurement and the mean value of two or more; (b) the average of several independent variations from the mean (the Average Deviation) (c) the root-mean-square value computed from several individual deviations (this is the Standard Deviation) or (d) the ratio of (a) or (b) or (c) to the mean. In any case the number of observations should be stated.

805. SENSITIVITY is the ratio of output response to a specified change in the input.

This term can be applied to any element in the control loop. For a measuring instrument the input is the measured variable; for an automatic controller it is the controlled variable.

For example, an automatic temperature controller having a net output pressure of 15 psi and a full scale range of 0 to 150 F would have a sensitivity of 0.1 psi per degree F.

Where nonlinear relationships are involved the point or points at which the sensitivity is given should be stated.

806. RESOLUTION SENSITIVITY is the minimum change in the measured variable which produces an effective response of the instrument or automatic controller.

Resolution sensitivity may be expressed in units of the measured variable or as a fraction or per cent of the full scale value, or the actual value.

807. THRESHOLD SENSITIVITY is the lowest level of the measured variable which produces effective response of the instrument or automatic controller.

808. DEAD BAND is the range of values through which the input can be varied without initiating output response.

809. HYSTERESIS is the difference between the increasing input value and the decreasing input value which effect the same output value. This term applies only where the output value is a continuous function of the input value.

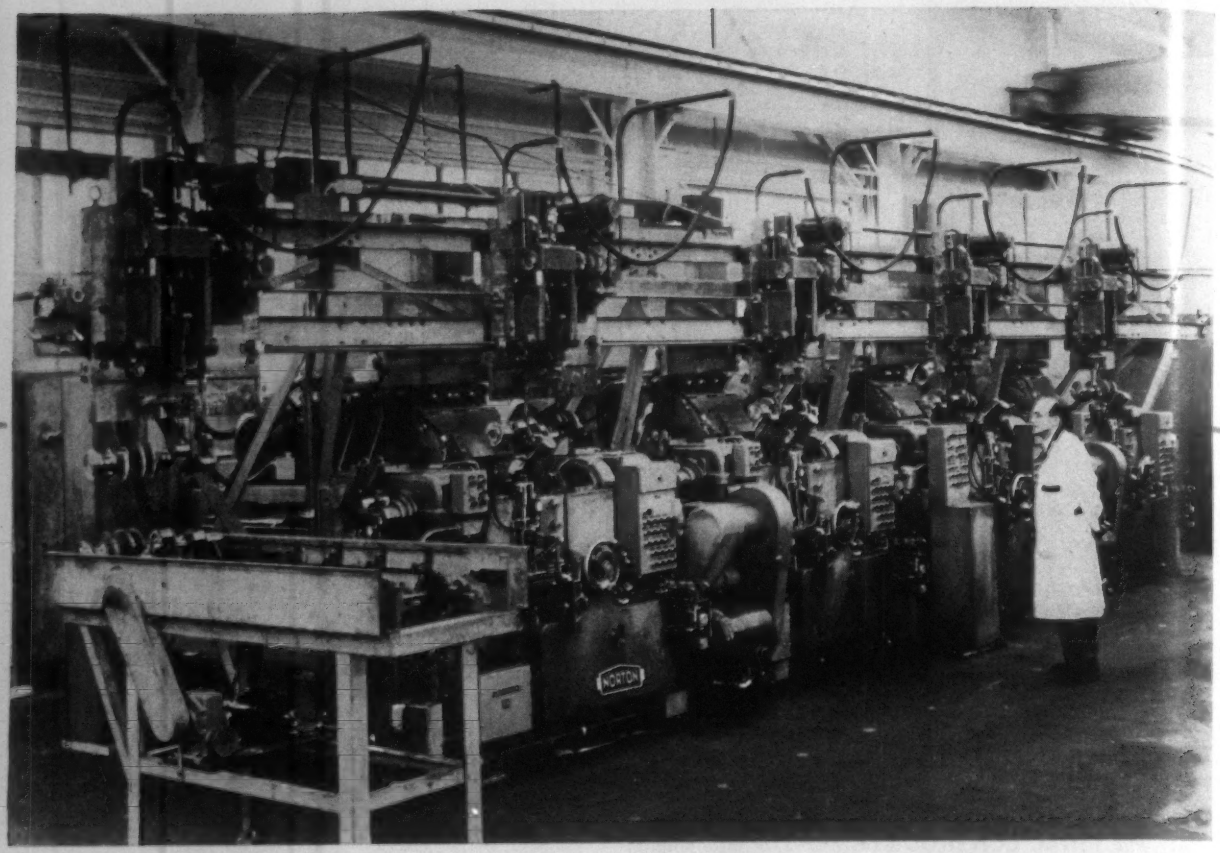


Fig. 1—Norton crankpin grinder of transfer design. Controls at each station of automated unit are used during setting up operations. Central station controls all units of the machine. The first machine to be completed is scheduled for delivery to the Studebaker-Packard Corp.

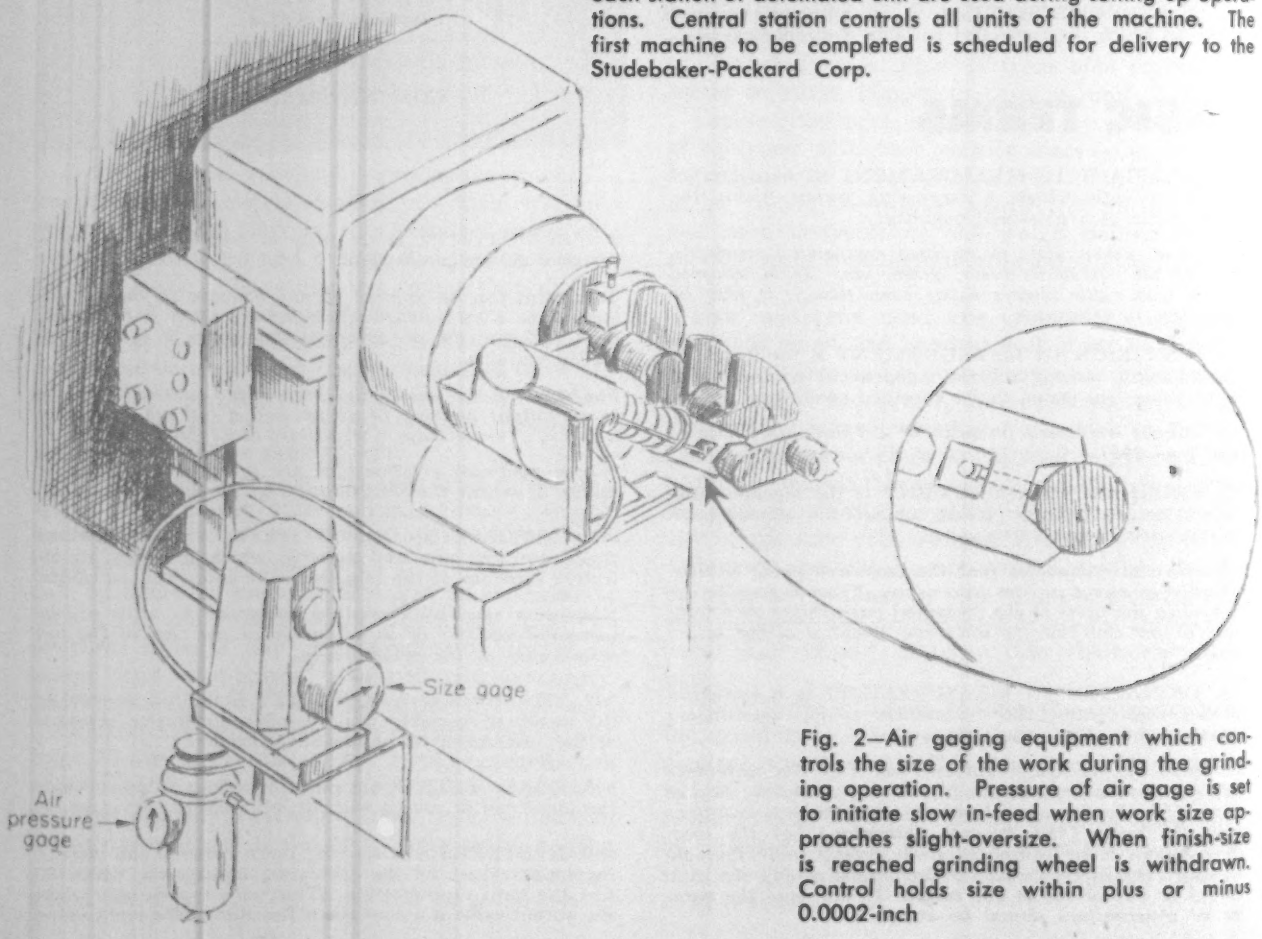
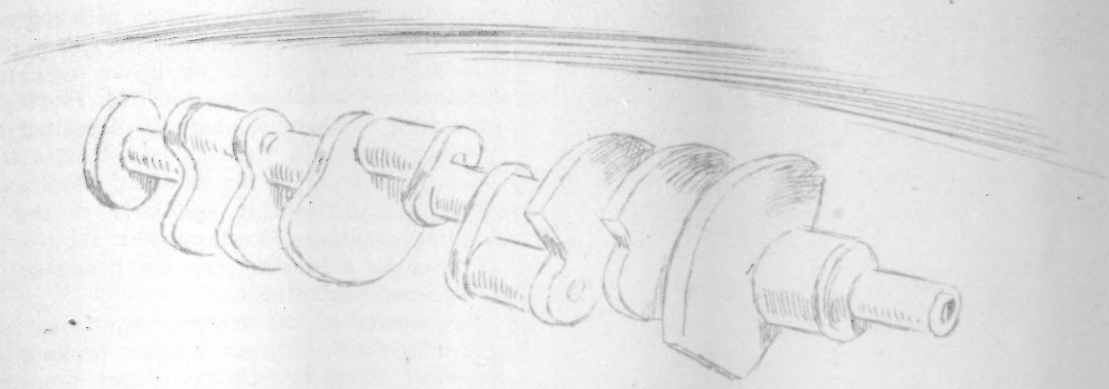


Fig. 2—Air gaging equipment which controls the size of the work during the grinding operation. Pressure of air gage is set to initiate slow in-feed when work size approaches slight-oversize. When finish-size is reached grinding wheel is withdrawn. Control holds size within plus or minus 0.0002-inch



CONTINUOUS CRANKSHAFT GRINDING

USES TRANSFER SYSTEM

AUTOMATION, as generally known in the machine tool industry, means performing machining operations automatically and handling work between operations without hand labor. The highest form of this automation in metalworking probably exists in the automobile industry where castings of engine parts leave the foundry and proceed through the various machining operations without a human hand touching them. Many of these operations have been done automatically for several years.

Precision grinding, however, has resisted automation efforts to a certain degree because it has not been possible to obtain the close tolerances required of mating parts without human attention. Recently, the Norton Co. has completed a transfer type grinder designed to mechanize all operations necessary for accurately grinding the bearings of chankshafts automatically, *Fig.* 1. When using these machines, the operator merely observes while all grinding and handling functions are accomplished automatically and continuously.

As the crankshaft proceeds from one grinding station to the next, succeeding journals are ground until the shaft is finally deposited on a conveyor line completely ground. The machine has a grinding station for each crankpin of the crankshaft.

In addition to the actual motions involved in loading, unloading and grinding, an important element of the transfer grinder is automatic truing of the grinding wheels at predetermined intervals—after each grind or a number of grinds as may prove most economical. As the wheel is trued, there is automatic compensation made in the wheel speed and in the feed mechanism for reduction in diameter of the grinding wheel. Air-operated gages, which measure pin diameter during grinding, control the in-feed of the grinding wheel, *Fig.* 2.

The new machine is built in sections, *Fig.* 3, each base section supporting two wheelheads which run on flat and vee ways. Each wheelhead carries a 42-inch diameter grinding wheel driven by its own 25-hp, dc variable-speed motor. The wheel is mounted on a spindle running in sleeve bearings—one bearing on each side of the wheel. Each base section supports two pairs of workheads which are driven by a single motor.

Wheel feed is operated hydraulically with a rapid motion by cylinder and piston which moves

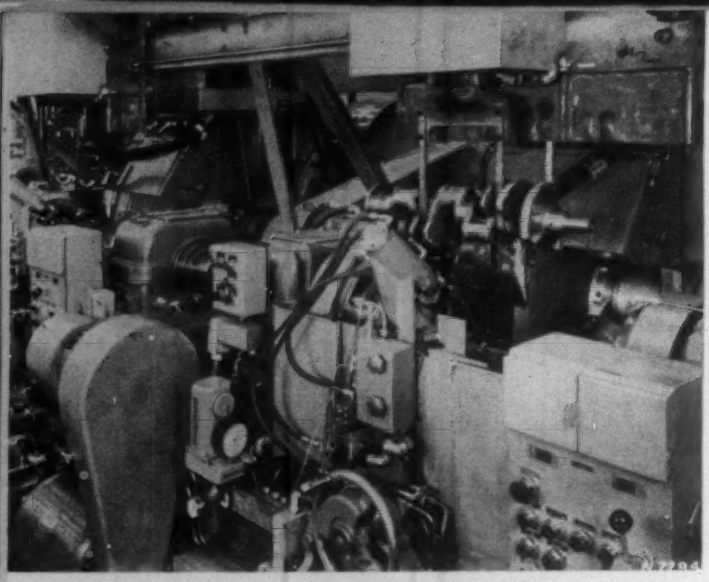


Fig. 3—One of four grinding stations of the crankpin grinder. Size is controlled by the air gage just below the crank which is being lowered by the transfer hook into the work heads. Crank is automatically and accurately located both lengthwise and angularly by the work holders

the complete unit. Actual feed for grinding the body of the crankpin is accomplished by a large diameter feedscrew which is revolved in its nut.

▶ Workpiece Transfer

The transfer mechanism consists of an overhead track which is supported by a fabricated steel framework and extending the whole length of the unit from loading to unloading conveyor stations, *Fig.* 4. The transfer heads travel vertically to pick up and deposit the crankshafts at each station, moving simultaneously. When moving horizontally to transfer the work between stations, all heads move in unison (they are joined together). Cranks in process are moved one station to the right for grinding of succeeding pins or placing in the conveyor station for transfer to the next type of operation. While actual grinding is being done, traveling heads return to the pickup position.

In addition to the lifting hooks, each transfer station contains a locating hook for rough angular orientation. When a shaft is deposited in any grinding station, a rotating cam locates it longitudinally in front of the grinding wheel and a locating arm adjusts it angularly to the proper grinding position. Final angular location is determined by a locating pin which engages a hole in the crankshaft flange.

Movements of the transfer equipment are operated by four ½-hp ac dynamic braking motors; electrical interlocks insure proper sequence and stop the whole procedure should any part of the transfer or grinding equipment fail. Movements are timed and controlled to stop and start without noise or jar and to travel rapidly between stations.

Grinding time for a complete crankshaft, including all crankpin journals and adjacent shoulders is comparable to that of a good operator working at top speed on a modern conventional type of crankpin grinder grinding a single crankpin. However, once in full operation, cycle time per shaft equals that required to grind and handle only one crankpin. Being completely automatic, the machine operates at close to 100 per cent efficiency, producing 45 to 60 completed pieces per hour. The machine can be preset to operate at a definite rate of production continuously.

Should it be necessary to shut down any station for adjustment or repairs, the unit can be controlled to operate in such a way as to by-pass the inoperative station. A stand-by conventional crankpin grinder can be used to grind the crankpin skipped by the automatic unit in this event. If the transfer equipment should fail, individual grinding stations can be manned by operators and production resumed.

It has been estimated that this automated crankpin grinder will allow one man to do the work of five to seven men using conventional semiautomatic grinding machines. On the face of it, this would seem to mean that several operators would be pushed out of jobs. In practice, however, these men are usually absorbed into maintenance jobs where their skills can be used to good advantage.

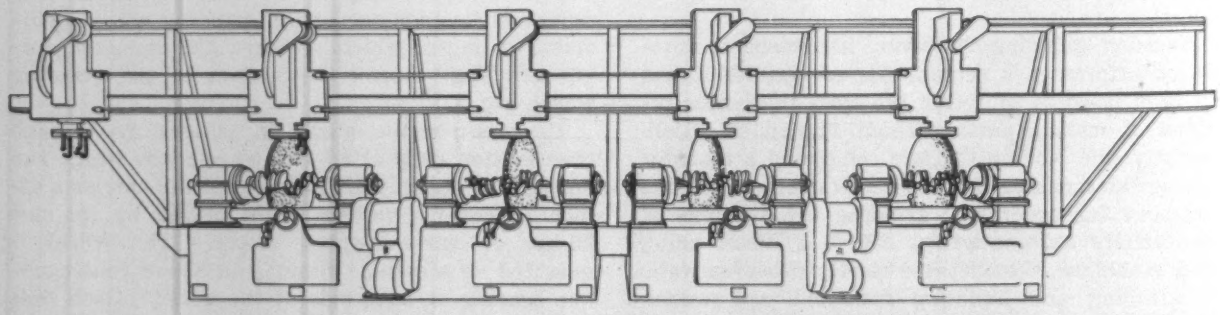
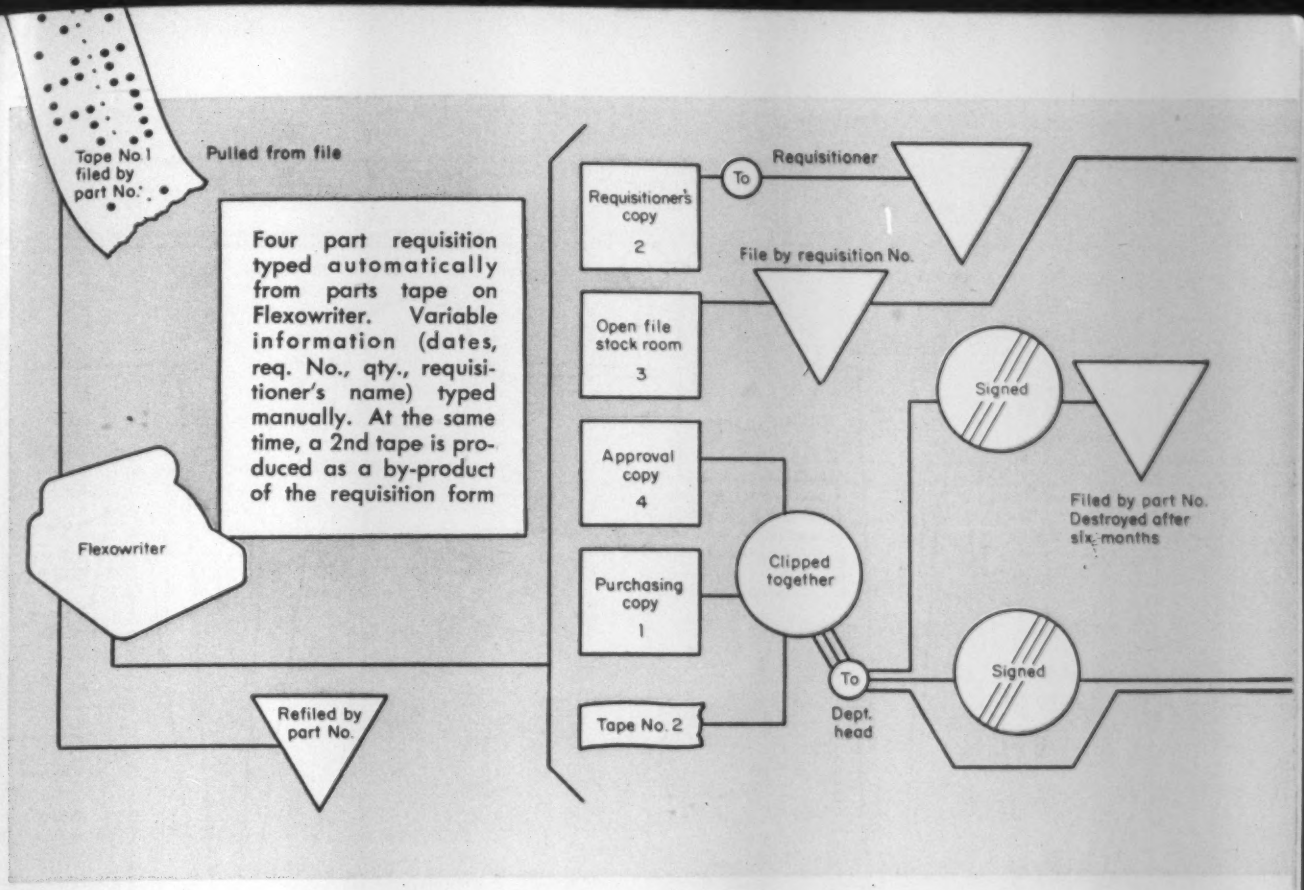


Fig. 4—Sketch of Norton crankpin grinder showing overhead transfer mechanism and four grinding stations. Crankshafts are picked up and moved to the right simultaneously, one end receiving a new piece, the other placing a shaft on the conveyor completely ground


Tape No. 1 filed by part No.
Pulled from file
Four part requisition typed automatically from parts tape on Flexowriter. Variable information (dates, req. No., qty., requisitioner's name) typed manually. At the same time, a 2nd tape is produced as a by-product of the requisition form
Flexowriter
Refiled by part No.
Requisitioner's copy 2
To
Requisitioner
File by requisition No.
Open file stock room 3
Signed
Approval copy 4
Filed by part No. Destroyed after six months
Clipped together
Purchasing copy 1
To
Dept. head
Signed
Tape No. 2

INTEGRATED DATA PROCESSING BRINGS AUTOMATION TO PAPERWORK

PART 3

By P. B. GARROTT
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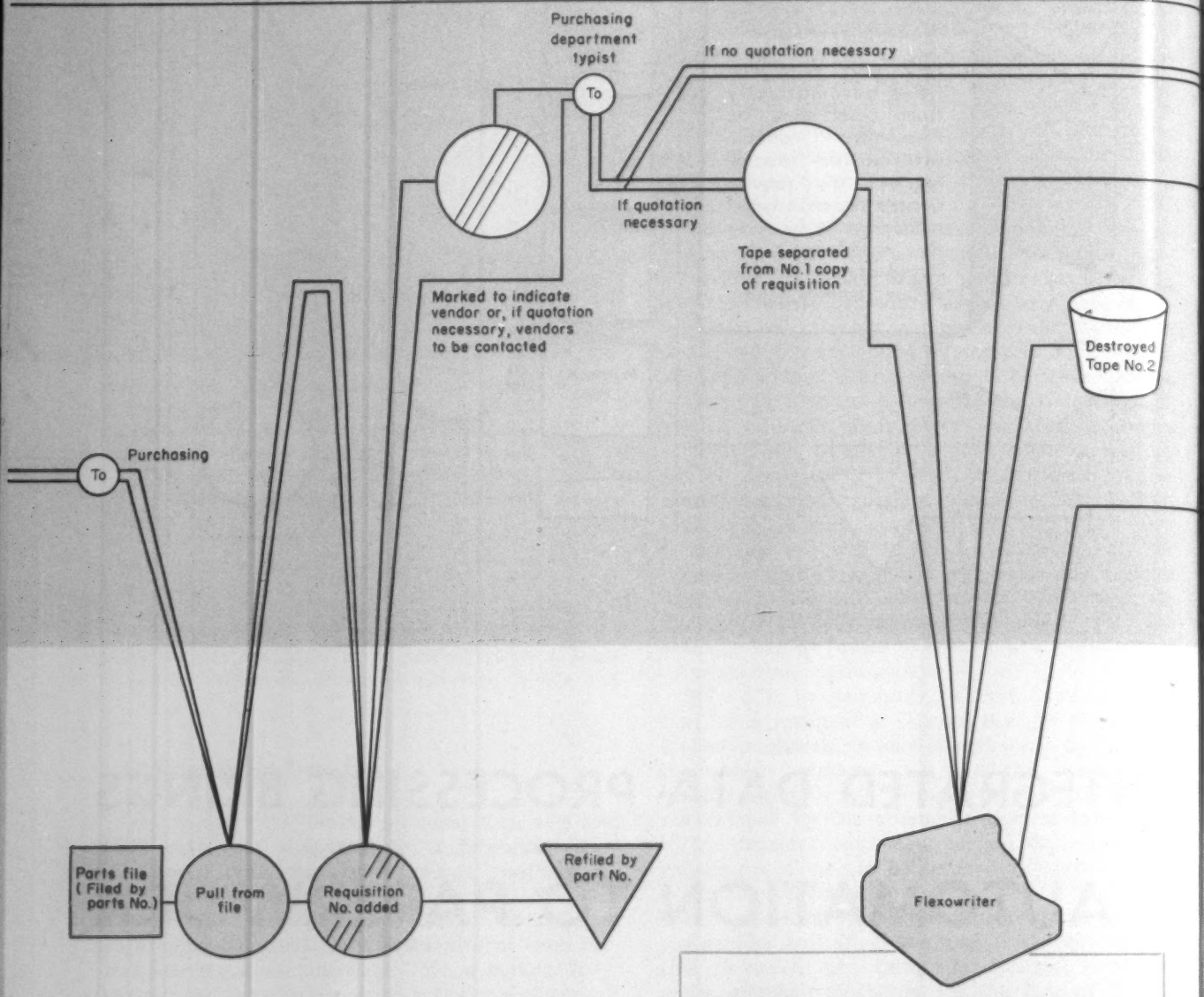
Standard Register Co.
Dayton, Ohio

There's still a long road between integrated data processing principles, an illustrative example and the solution to *your* processing problems. In this third article of the series, guideposts point toward successful application of the common language idea that can eliminate delays and frustration in your pursuit after peace of mind in data processing

PRINCIPLES of integrated data processing and an illustration of their application to a common business control system—the purchasing-receiving operation—have been presented in the preceding articles of this series. Common language tape has been described, along with its ability to mechanize repetitive clerical tasks by automatically operating and reoperating office machines of various types with superhuman speed, accuracy and economy.

These earlier remarks were intended, mainly, to demystify integrated data processing so management people could more readily appreciate its possible value. It was presented in general terms to make clear the broad application in bringing a high-



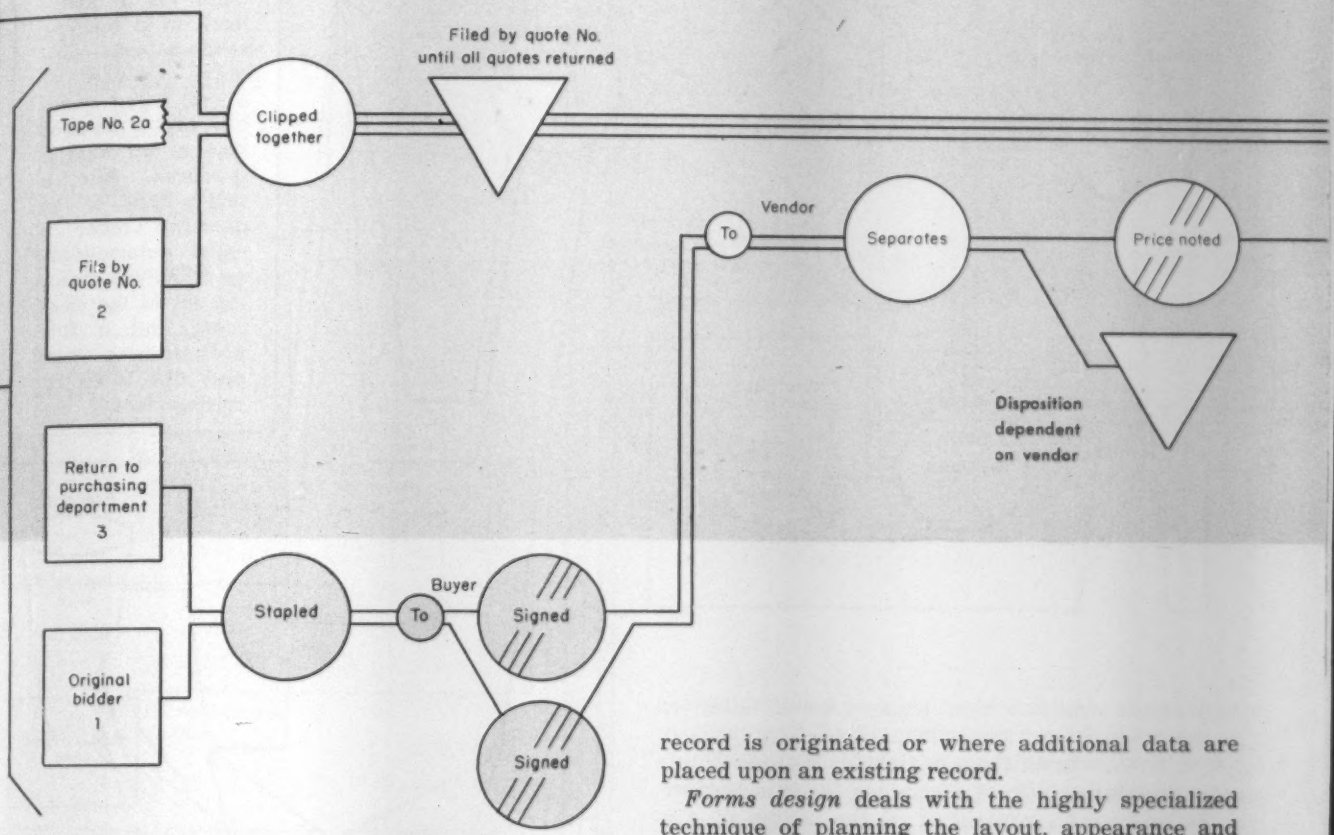
Three part request for quotation typed automatically by No. 2 tape on Flexowriter. Variable information typed manually (vendor name and address, date). At the same time a tape is produced as a by-product of the request for quotation

er degree of automation to paperwork—along with many of the cost cutting, profit boosting benefits normally expected from automation.

This article, which concludes the current series, is based upon the assumption that integrated data processing as an idea has been established as an attractive, potentially valuable management tool. Individual reaction at this point is likely to be, "Yes, it sounds good and makes sense, but how can *I* get some benefit from it?" Many of the basic answers to this question will be provided and ways in which other unanswered questions may be individually resolved will be suggested.

Obviously, the subject of integrated data processing is not easy to explore and define fully. This necessarily general nature of presentation won't make you a master of integrated data processing, but it will give you the rules and some guiding suggestions which will enable you to play the game reasonably well—practice will do the rest.

By the very nature of the integrated idea, its application is going to do the most good in those control systems where masses of data are being processed sequentially by many different people and departments with each step predicated to some extent upon information supplied to it by the preceding step. In such cases, since a number of different departments and functions are likely to be



involved, integrated data processing is a top management tool rather than a departmental device.

How to Attack the Problem

There are three major areas to any paperwork problem, each of which must be thoroughly investigated before any data processing system can be installed.

Procedure is that nebulous network of loosely knit steps, people, operations and equipment through which vital business information is processed. It is concerned with and includes every phase and aspect of data handling from origin in an organization until ultimate disposition. In paperwork procedures, the only tangible evidence of such processing is secured by analyzing, observing and recording every step in the processing of forms or documents bearing pertinent data.

Writing process includes all the physical equipment, forms, devices and machines used in recording data at every point in the procedure where a record is originated or where additional data are placed upon an existing record.

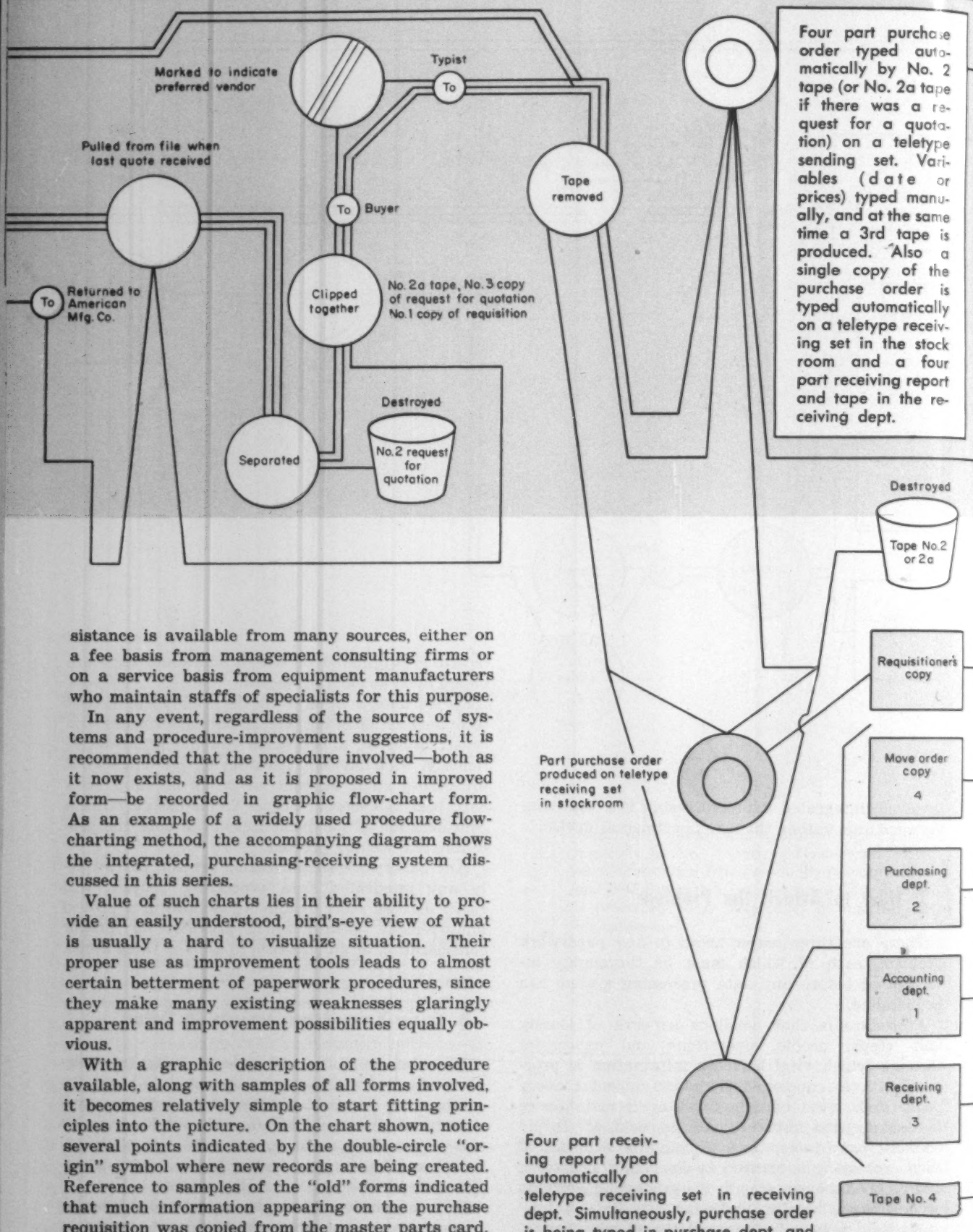
Forms design deals with the highly specialized technique of planning the layout, appearance and construction of a record to provide greatest efficiency, economy and accuracy in its subsequent processing steps as well as in its creation as a data bearing record. Proper forms design reflects consideration of pertinent aspects in both the procedure and writing process.

Any paperwork simplification project, particularly any integrated data processing project, will reach success more readily by following a proved improvement pattern which provides for proper consideration of all elements in each of these areas.

Know Your Requirements in Detail

Procedure is of the widest scope, being the overall network of which other areas are only part. To achieve the greatest possible degree of improvement then, first consideration should be given to this master plan, to be sure that it is as clear, efficient and logical as possible, before trying to refine individual steps which it contains.

It is not within the purpose or scope of this series to provide a procedure improvement textbook. Many organizations have competent systems specialists on their staffs. To others, qualified as-


Marked to indicate preferred vendor
Typist
To
Pulled from file when last quote received
To Buyer
Tape removed
To
Returned to American Mfg. Co.
Clipped together
No. 2a tape, No. 3 copy of request for quotation
No. 1 copy of requisition
Destroyed
Separated
No. 2 request for quotation
Four part purchase order typed automatically by No. 2 tape (or No. 2a tape if there was a request for a quotation) on a teletype sending set. Variables (date or prices) typed manually, and at the same time a 3rd tape is produced. Also a single copy of the purchase order is typed automatically on a teletype receiving set in the stock room and a four part receiving report and tape in the receiving dept.
Destroyed
Tape No. 2 or 2a
Requisitioner's copy
Part purchase order produced on teletype receiving set in stockroom
Move order copy
4
Purchasing dept.
2
Accounting dept.
1
Receiving dept.
3
Tape No. 4

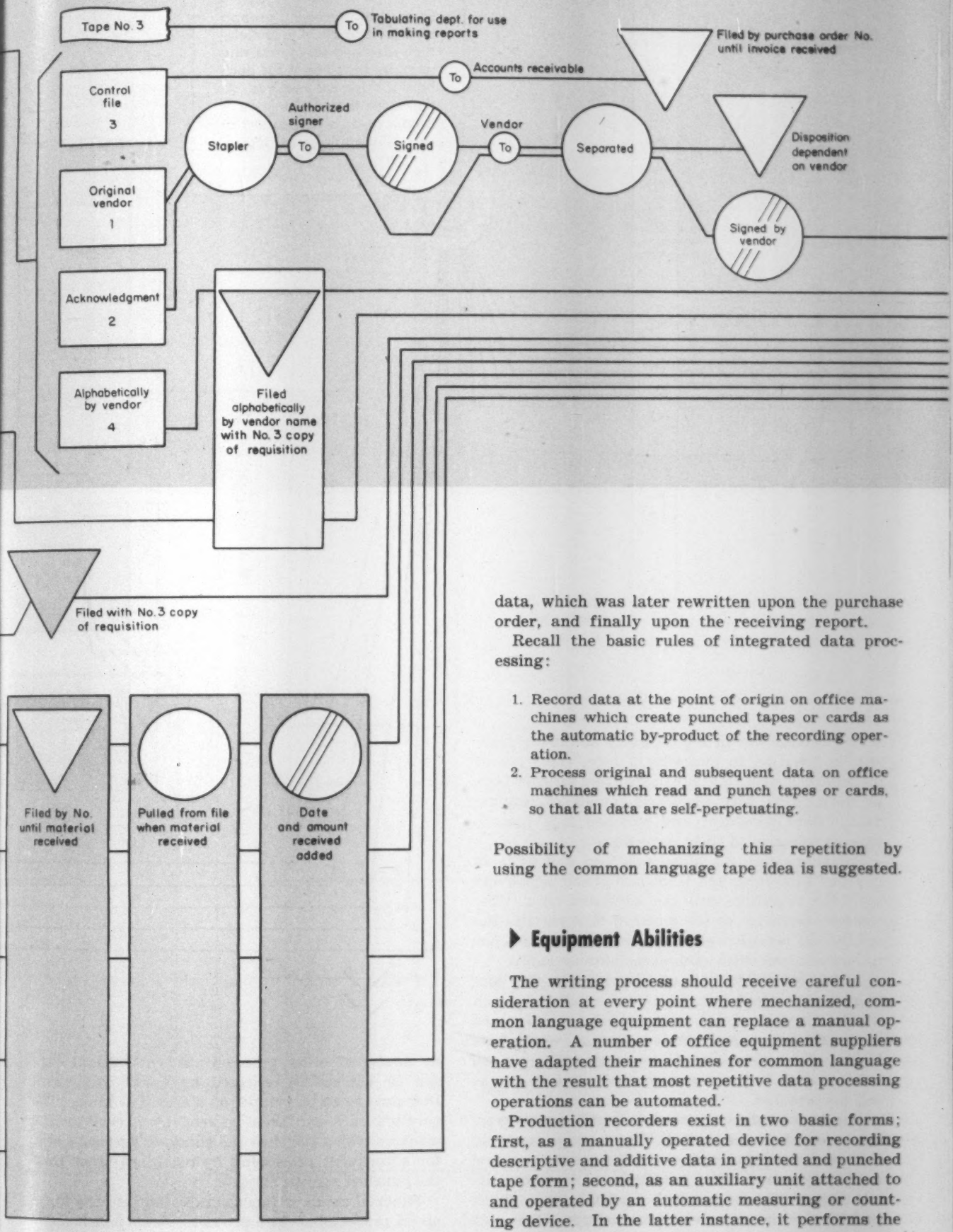
Four part receiving report typed automatically on teletype receiving set in receiving dept. Simultaneously, purchase order is being typed in purchase dept. and a 4th tape is produced as a by-product of the receiving report

sistance is available from many sources, either on a fee basis from management consulting firms or on a service basis from equipment manufacturers who maintain staffs of specialists for this purpose.

In any event, regardless of the source of systems and procedure-improvement suggestions, it is recommended that the procedure involved—both as it now exists, and as it is proposed in improved form—be recorded in graphic flow-chart form. As an example of a widely used procedure flow-charting method, the accompanying diagram shows the integrated, purchasing-receiving system discussed in this series.

Value of such charts lies in their ability to provide an easily understood, bird's-eye view of what is usually a hard to visualize situation. Their proper use as improvement tools leads to almost certain betterment of paperwork procedures, since they make many existing weaknesses glaringly apparent and improvement possibilities equally obvious.

With a graphic description of the procedure available, along with samples of all forms involved, it becomes relatively simple to start fitting principles into the picture. On the chart shown, notice several points indicated by the double-circle "origin" symbol where new records are being created. Reference to samples of the "old" forms indicated that much information appearing on the purchase requisition was copied from the master parts card. In the same manner, the requisition served as source record for copying request for quotation



data, which was later rewritten upon the purchase order, and finally upon the receiving report.

Recall the basic rules of integrated data processing:

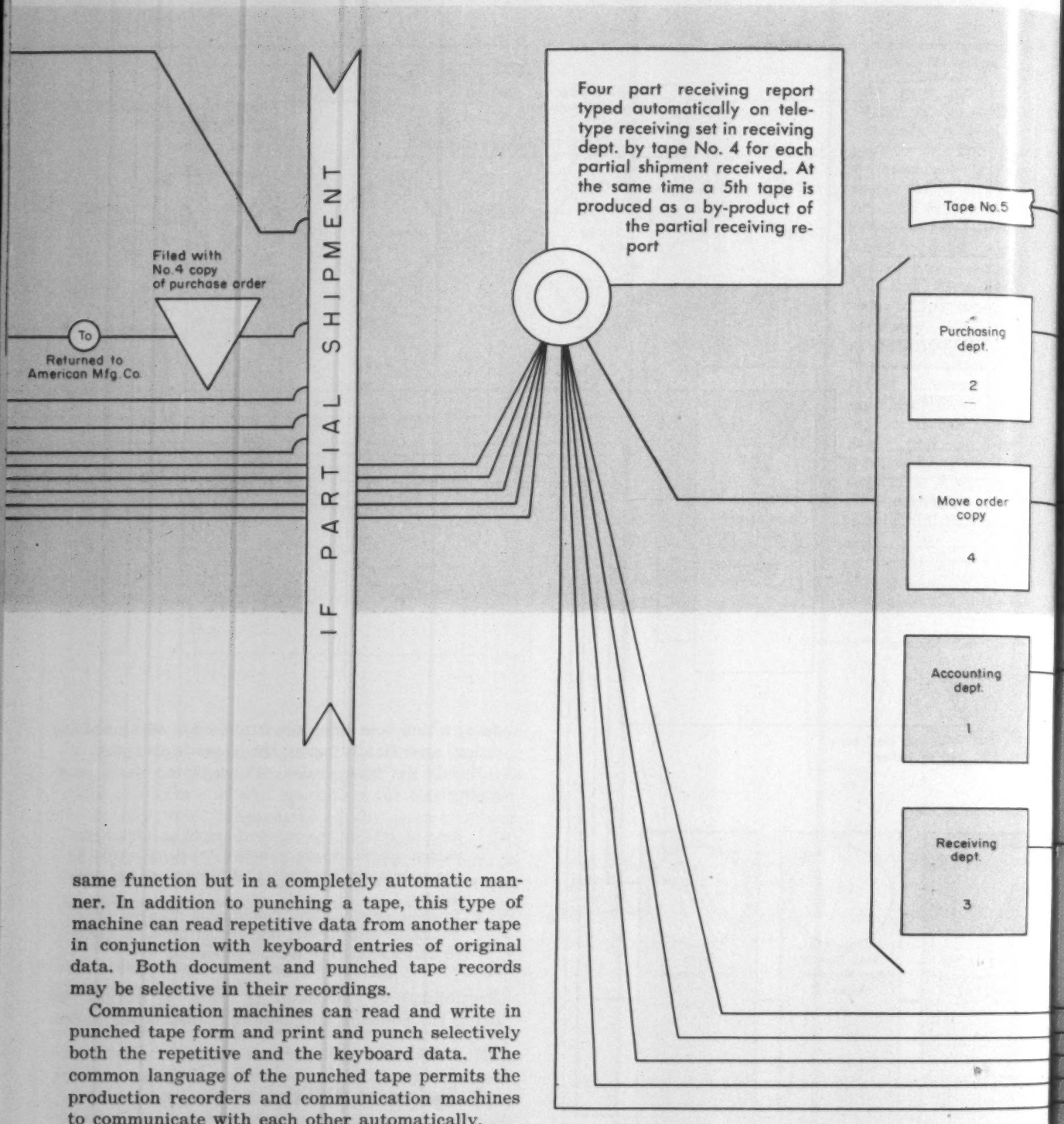
1. Record data at the point of origin on office machines which create punched tapes or cards as the automatic by-product of the recording operation.
2. Process original and subsequent data on office machines which read and punch tapes or cards, so that all data are self-perpetuating.

Possibility of mechanizing this repetition by using the common language tape idea is suggested.

▶ Equipment Abilities

The writing process should receive careful consideration at every point where mechanized, common language equipment can replace a manual operation. A number of office equipment suppliers have adapted their machines for common language with the result that most repetitive data processing operations can be automated.

Production recorders exist in two basic forms; first, as a manually operated device for recording descriptive and additive data in printed and punched tape form; second, as an auxiliary unit attached to and operated by an automatic measuring or counting device. In the latter instance, it performs the


IF PARTIAL SHIPMENT
Filed with No.4 copy of purchase order
To
Returned to American Mfg. Co.
Four part receiving report typed automatically on teletype receiving set in receiving dept. by tape No. 4 for each partial shipment received. At the same time a 5th tape is produced as a by-product of the partial receiving report
Tape No.5
Purchasing dept. 2
Move order copy 4
Accounting dept. 1
Receiving dept. 3

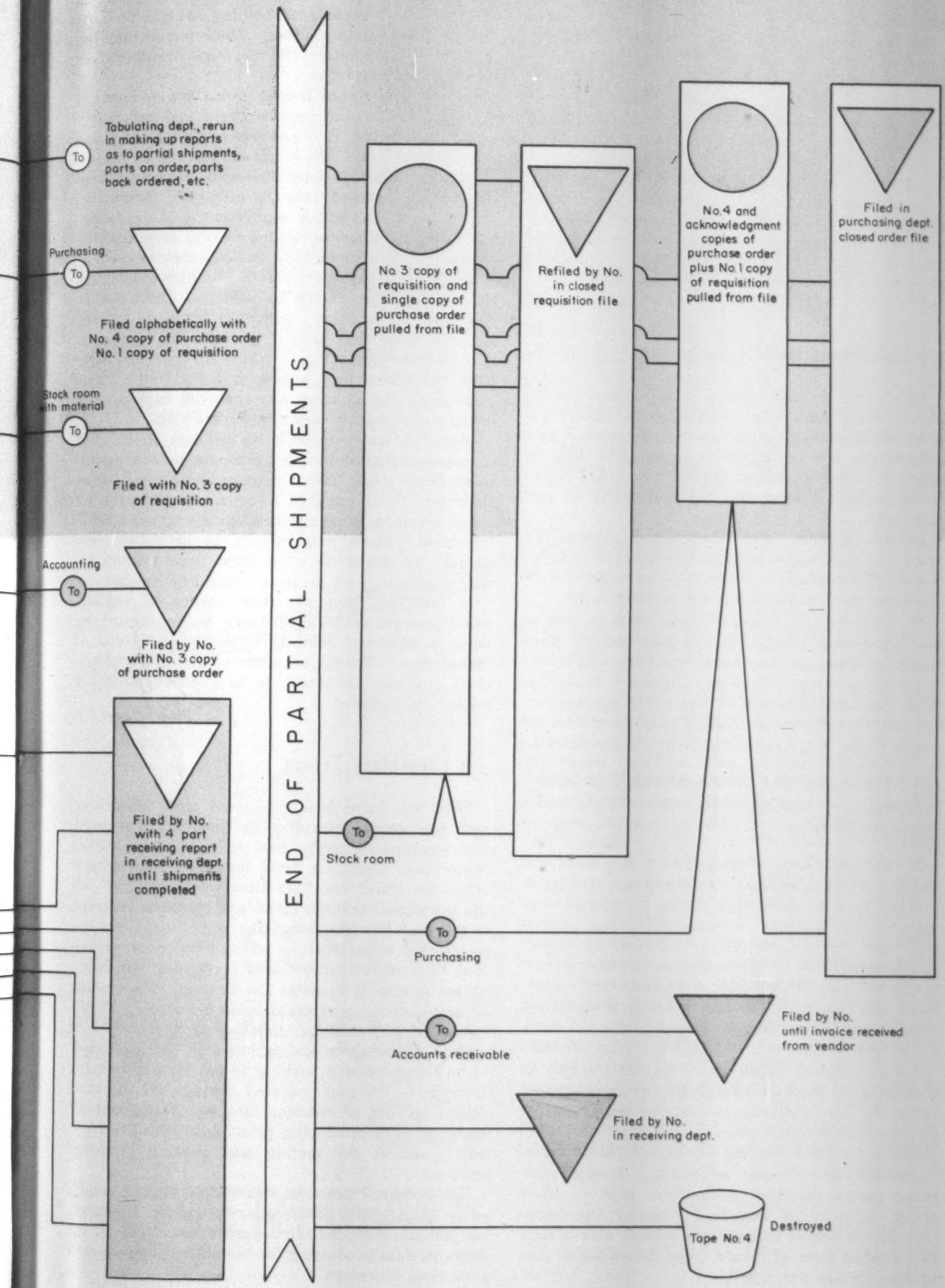
same function but in a completely automatic manner. In addition to punching a tape, this type of machine can read repetitive data from another tape in conjunction with keyboard entries of original data. Both document and punched tape records may be selective in their recordings.

Communication machines can read and write in punched tape form and print and punch selectively both the repetitive and the keyboard data. The common language of the punched tape permits the production recorders and communication machines to communicate with each other automatically.

Typewriters, adding machines, bookkeeping machines, and calculators, again can read and punch a tape. They can accept keyboard entries and record in punched tape and printed form on a selective basis. They all speak the same language, record original data in punched tape, and all data can be self-perpetuated.

Punched card equipment and high-speed processors can be used through tape-to-card machines that read common language and create the punched card unit record. The punched card is automatically interpreted by punched card machines which provide for the entry of additional repetitive data by means of other punched cards. Original data can be entered by selected keyboard equipment. Documents can be printed on a selective basis. The punched card can then be read by a card-to-tape machine which punches the common language tape for subsequent processing by machines other than the punched card variety.

Punched cards or tapes can be fed into the high-speed processors. The processors can punch cards


Tabulating dept., rerun in making up reports as to partial shipments, parts on order, parts back ordered, etc.
To
Purchasing
To
Filed alphabetically with No. 4 copy of purchase order No. 1 copy of requisition
Stock room with material
To
Filed with No. 3 copy of requisition
Accounting
To
Filed by No. with No. 3 copy of purchase order
Filed by No. with 4 part receiving report in receiving dept. until shipments completed
END OF PARTIAL SHIPMENTS
No. 3 copy of requisition and single copy of purchase order pulled from file
Refiled by No. in closed requisition file
No. 4 and acknowledgment copies of purchase order plus No. 1 copy of requisition pulled from file
Filed in purchasing dept. closed order file
To
Stock room
To
Purchasing
To
Accounts receivable
Filed by No. until invoice received from vendor
Filed by No. in receiving dept.
Tape No. 4
Destroyed

for subsequent punched card machine operations and the common language punched tape for other machines.

Finally, in the area of forms design, each of the proposed new forms is planned, designed and created to permit it to perform as an integrated part of the overall system. Information common to two or more of these forms is located in identical positions on each form, so by-product common language tape resulting from the writing of one record can be used to write others automatically. Scientific forms design within integrated data processing systems requires careful consideration of many more factors than can be mentioned here, but that need be of no particular concern since competent assistance is available on such problems.

▶ Additional Helpful Techniques

In addition to this recommended pattern for applying integrated data processing to paperwork procedures, several other related comments and suggestions are in order. These remarks will be made in rather a random fashion since they relate to the overall subject and not specifically to any one phase.

Errors in tapes may be corrected easily. We shall use the tape-reading, tape-punching typewriter as the machine in our example since it is the type most widely used for making tapes.

If the error is a "sensed" error—that is, one or two keystrokes which the operator realized were wrong as soon as she struck the keys—the tape-punching unit may be turned backward manually. With the error returned to the punching position, the operator strikes the "LTRS" key once for each wrong code. Each such keystroke causes holes to be punched in all five code positions across the tape, obliterating the erroneous codes by replacing them with a nonprinting code. Correct codes are then punched into the tape in the regular manner.

If the error is discovered after a document and its by-product tape have been completed, the error bearing tape is inserted into the reading unit to operate the machine automatically, punching a new tape. As the point of error is reached (known by referring to the original document where the error is marked) the operator stops the reading unit; skips the tape past the error to the next correct code; types the correction; then restarts the reader, letting it complete duplication of the old tape.

Since punched tapes are frequently used as master tapes to enter nonvariable or repetitive information automatically in common language machines, consideration must be given to improved methods for the filing and finding of master tapes.

Probably the simplest method for tapes of moderate length involves folding the tape in loops about eight inches long and dropping the folded tape into a pocket formed by doubling over a copy of a related form or record. The folded paper may then be filed as a document.

Another tape-filing arrangement consists of thin, flat plastic sheets having ten pockets or slots on the face, each capable of holding several feet of tape in fully visible position. These panels may be filed in regular letter file drawers or stored in a modified tub type file.

In instances where master tapes are numerous, short in length, and require rapid and repetitive filing and finding, it is possible to punch the five-channel code along the longitudinal edge of a tabulating card, interpret or label as desired, and then file behind indexed tabs in standard tabulating card tab or drawer file equipment. Other methods include rolling tapes and storing in microfilm boxes and files or in thread-spool drawers.

In general, tapes should be discarded and destroyed as soon as the information contained is recorded in common language form elsewhere. Keep in mind that once a tape has been used in a subsequent operation in which its contents have been duplicated into a new and still more complete tape, the chances are that the earlier tape could and should be destroyed forthwith.

Identification of tapes is no problem in the case of tapes produced by wire communications equipment since these have the same data typed upon their face as is punched in code. Tapes made by other common language machines are not so interpreted. These may usually be identified adequately by pencilling upon them their related order, customer, part or some other key number.

In addition, general classification of various broad categories of tapes may be facilitated by using a different color of tape for each type of transaction. Thirty or more colors or combinations of colors are available, in a variety of paper weights and grades.

▶ Laboratory Tryout

Now you have been presented with integrated data processing principles, an illustrative example and suggestions as to how to reap the benefits from these ideas. A final lesson in this subject might be called the "practical work session." All the machines, devices, forms and methods referred to in these articles—together with many related paperwork simplification tools—have been assembled into an integrated data processing workshop by the Standard Register Co. through co-operation of many office equipment manufacturers. Facilities of this workshop, together with services of qualified specialists and technicians, are available to any organization wishing to see typical systems brought to life and operated through all essential phases by use of common language tapes and integrated data processing principles. Facilities are also available for testing and proving proposed systems.

The common language vehicle might be thought of as the transfer machine of the office. However, its potentials extend far beyond office doors; it integrates data processing for the entire business and industrial operation.

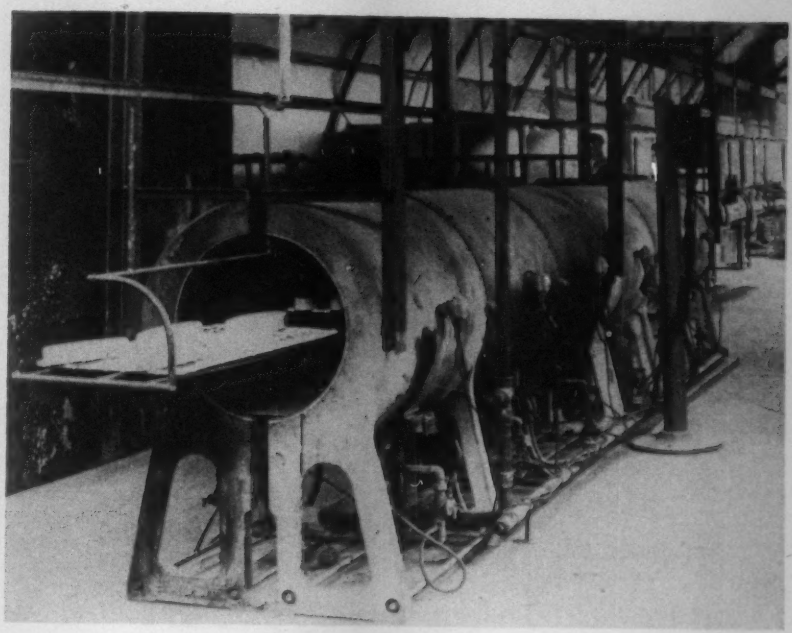
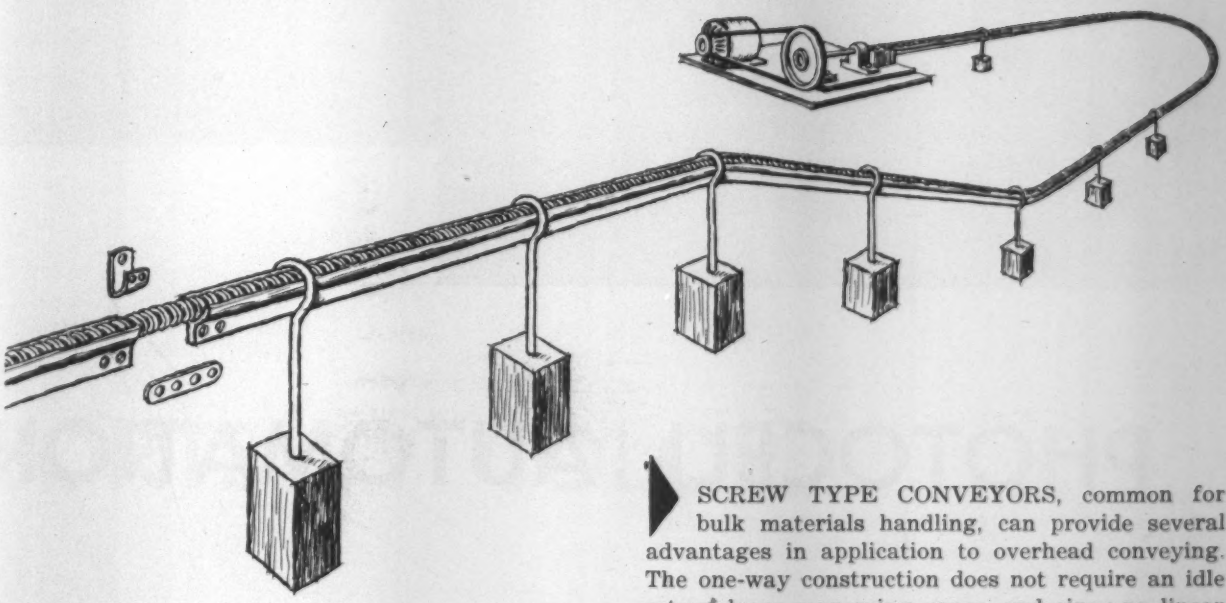


Fig. 1—Screw conveyor installation used to carry painted radio covers through a drying oven. Work-speeds up to 12 fpm are possible. Conveyor screw is driven by ½-hp, 1725 rpm motor; maximum load per foot of conveyor is 15 pounds. Load is propelled along rail by the exposed portion of the screw thread

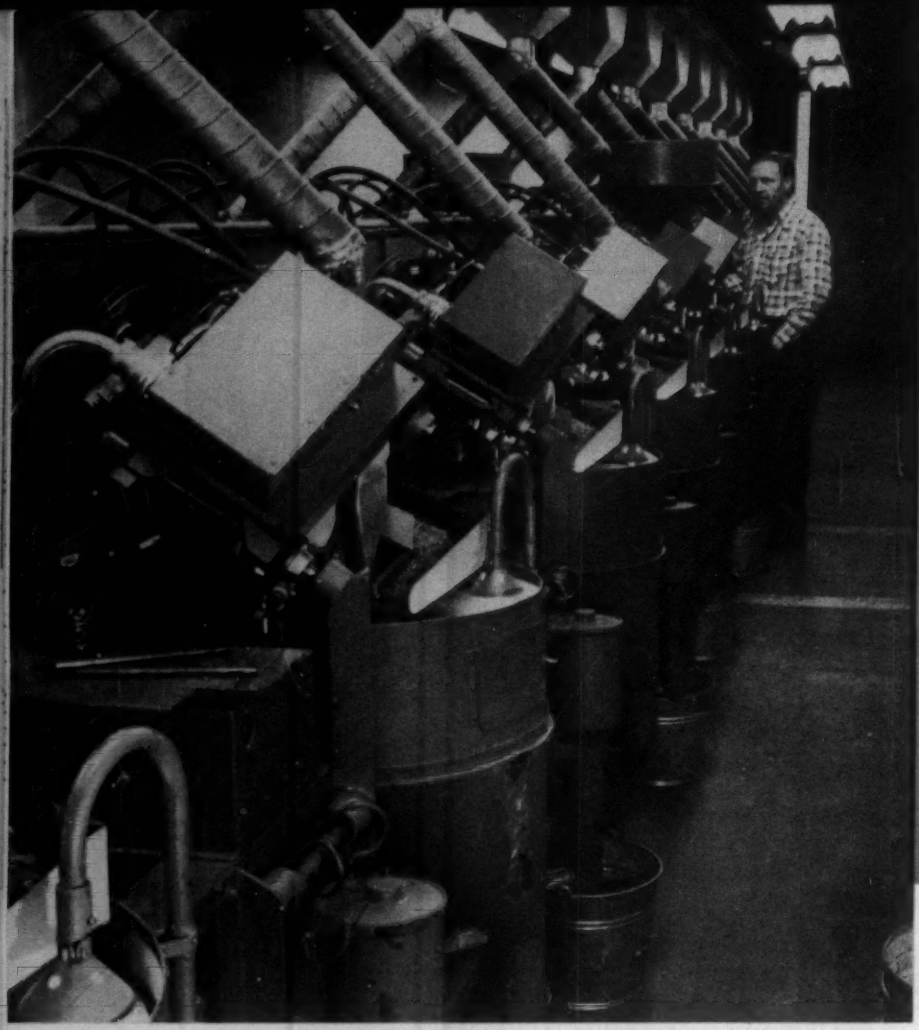


SCREW CONVEYORS GO OVERHEAD

SCREW TYPE CONVEYORS, common for bulk materials handling, can provide several advantages in application to overhead conveying. The one-way construction does not require an idle return loop, conserving space, and since no linear movement of the conveyor screw takes place, the conveyor does not cyclically pass through a work process.

A Monoflo system designed by M-H Standard Co. consists of a flexible high-carbon steel screw, approximately ¾-inch in diameter, that turns in a metal retaining rail with the top of the rail open to permit exposure of the screw, *Fig.* 1. When a load carrying hook is placed on the rail, the thread of the screw engages the hook and propels it along. Loads can be placed on the conveyor and removed from it at any point along its path. Items allowed to travel the full length of the conveyor can be transferred to another conveyor or accumulated on a gravity storage rail.

Installation of the system is adaptable to most overhead conditions with standard fittings and the conveyor route can include both horizontal and vertical bends.



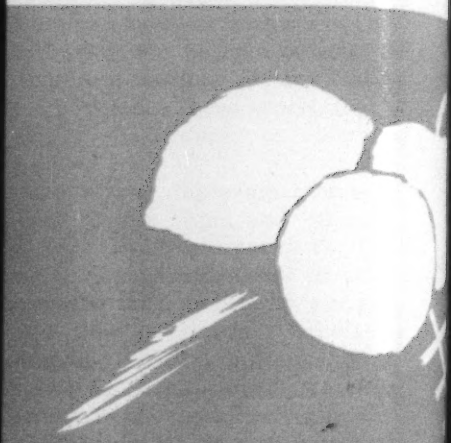


Fig. 1—Battery of sorting machines used by Otis McAllister & Co. for removal of off-color coffee beans. Almost indiscernible color differences in green beans are separated to produce a better product

PHOTOCELL AUTOMATION

AUTOMATIC SORTING techniques have been highly developed in many areas of measurement—size, weight, quantity, shape, and color. Often, color measurement is a direct indication of quality, or sometimes it is necessary to merely separate items of different hue or brightness. In either case, color sorting has many industrial applications.

Photoelectric sorting machines developed by the Electric Sorting Machine Co. have been adapted to food processing; to inspection of plating on small parts, textile clippings, and anodized aluminum rivets; to scanning of free-flowing substances; and to separation of different colored sprues and runners remaining from molded plastic products. In effect, most articles that require color sorting of the kind performed by hand labor can be sorted automatically. As in all automatic operations, this sorting can be done with greater speed and uniformity of discrimination than is possible with manual methods. Unlike hand sorting, capacity of automatic machines remains constant regardless of fluctuations in "randomness" of items.

Differences in color among objects may actually be of two kinds. In some instances, selection must be made in terms of relative brightness—the white distinguished from the gray, or the bright green from the dull green—for such operations special machines have been developed. Sorting may, however, also involve a selection in terms of hue—the separation of green from yellow, for example—among objects sharing the same degree of brightness. Other machines accurately perform this type of selection.

Older color sorting machines have handled pea-sized units; a new gravity-feed machine extends the principle of photoelectric selection to objects

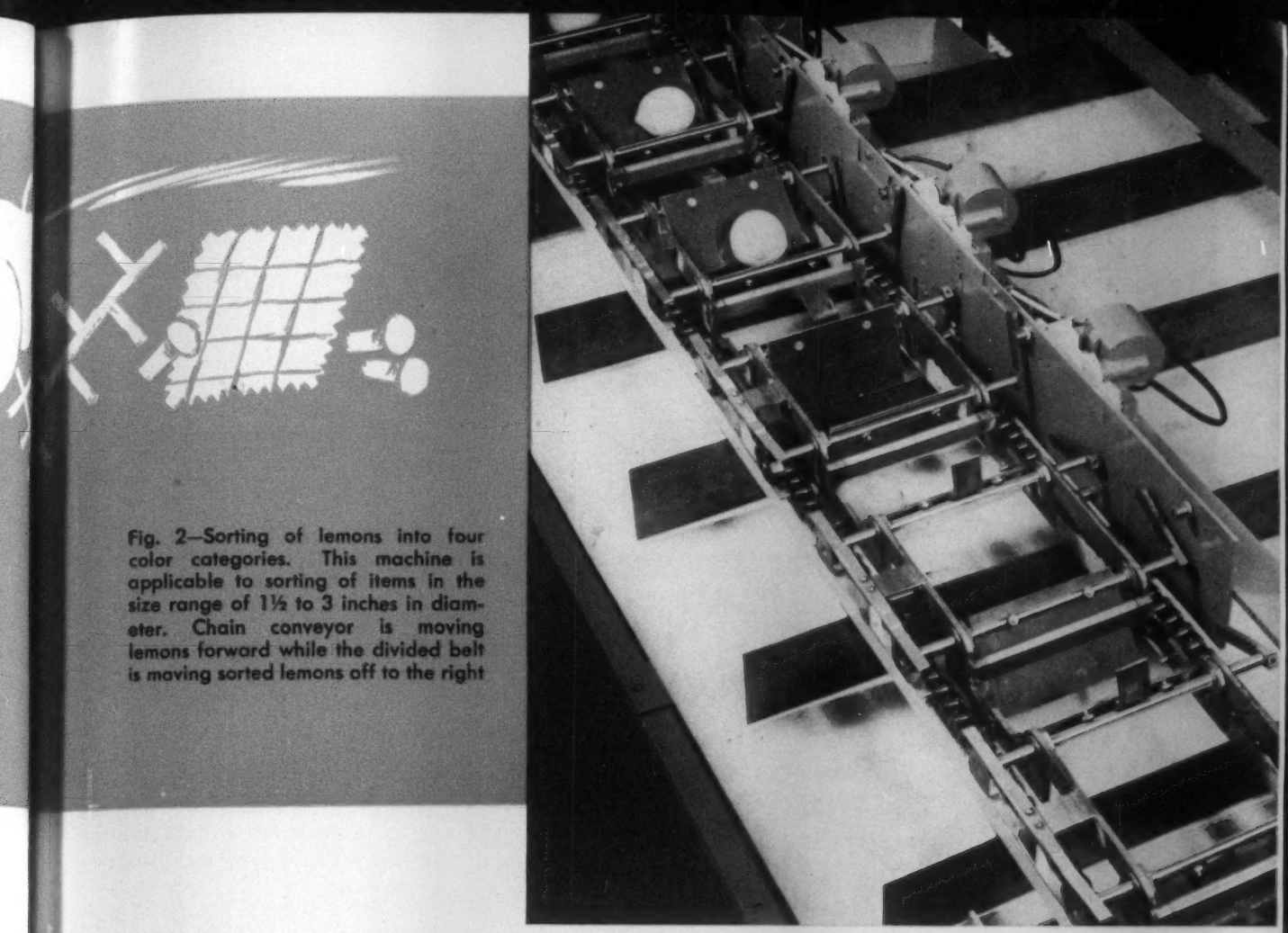


Fig. 2—Sorting of lemons into four color categories. This machine is applicable to sorting of items in the size range of 1½ to 3 inches in diameter. Chain conveyor is moving lemons forward while the divided belt is moving sorted lemons off to the right

SORTS BY COLOR

larger than any which have heretofore been automatically sorted. Designed initially for the lemon industry, machines sort lemons into four or more different color groups, and are equally applicable to the color sorting of most objects within the size range of 1½ to 3 inches in diameter. Potential applications, therefore, include not only fruits and vegetables in the approximate size range of apples or lemons, but many types of sorting in fields other than the food industry where automation can also provide real savings.

Essentially, all color sorting operations depend upon the phototube which can identify articles by responding to differences in the amount of light they reflect. Among the problems tackled in the development of the machines are those inherent in the phototube itself. Commercially successful separation depends upon extremely small signal responses. Hence, effects of vibration, changes in supply voltage, humidity, dust accumulation, were critical.

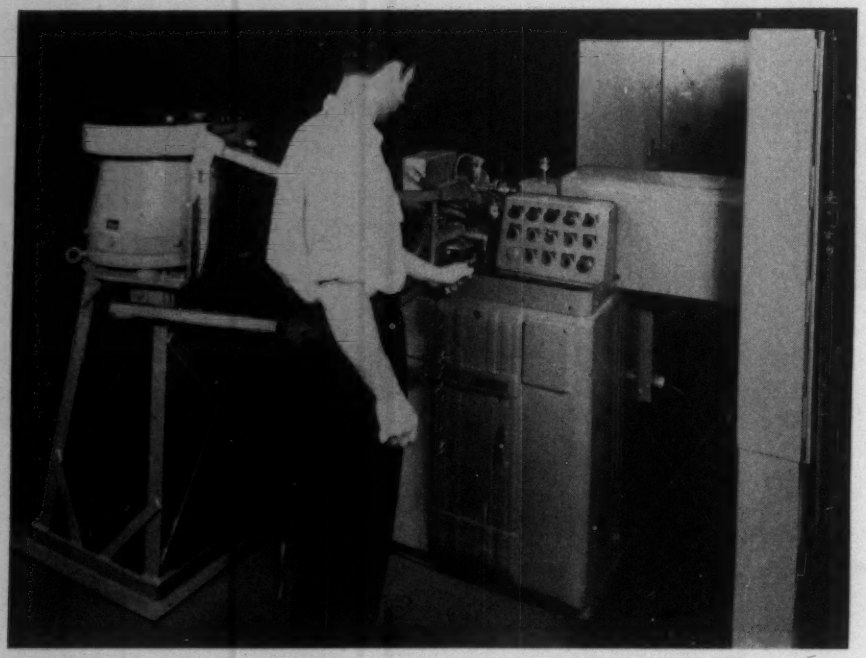
Beyond this, the sorting machine requires that objects at a constant rate of flow be rapidly presented to the phototube for inspection; that they be viewed individually against a uniform background, and under uniform light; and that the response of the phototube be amplified, "remembered," and transmitted to the ejecting device.

Photoelectric sorting machines can be relied upon to achieve and maintain uniformity of separation and productive capacity. Of equal importance, they can be preset to remove any desired percentage of culls, permitting the user to choose, in view of the character of unsorted stock, the particular final grade he wishes to make. Accordingly, he can use the machines to improve grade, or to salvage stock so high in cull content as to make hand sorting economically impractical.

AUTOMATION

NEW EQUIPMENT

Machines and plant equipment designed for more automatic operation



SOUND TEST INSPECTS GEARS AUTOMATICALLY

Automated gear speeder inspection unit loads, speeds spur and helical gears for sound test, and unloads them onto a conveyor line. All manual loading, unloading, and control functions are eliminated. Operator listens to the sound of the gears as they are rotated in contact with a master gear. He diverts any gears not meeting inspection standards for sound from the unloading chute. Gears are fed from a conveyor to a vibrating type hopper device, through an input chute, to the automatic loading device. Hopper feed operates intermittently, is controlled by the loading condition of the input chute. Loader feeds gears singly into mesh with the master gear. Gear is supported during the test by an expanding arbor that automatically enters and expands in the gear's bore.

Gear, in mesh with master gear, is run in one direction for a predetermined time until a brake load is applied. Upon brake load's release, gear is rotated in opposite direction until another brake load is automatically applied and master gear rotation is stopped. Push-buttons control each machine function. Because machine operates at minimum sound levels, separate electrical and pneumatic control panels are included, and these are mounted at a distance from the speeder unit. **National Broach & Machine Co.**, 5600 St. Jean Ave., Detroit 13, Mich.

Circle No. **1** *on Reply Card*

ROTATING CRANE

Necessity for crane ground crew is eliminated with this motorized, rotating crane hook because all operations are controlled by the craneman in his cab. Model illustrated is designed for use with existing crane blocks and has capacity of 40 tons. Models are available with capacities as low as one ton. A load cell can be incorporated with the hook to record each weight as it is lifted. Hook rotates through a full 360 degrees in either direction. It can be used with automatic tongs, magnets, or sheet lifters to turn loads to an exact position. "C" hook (illustrated) can turn a coil of steel horizontally as it is lifted. Electric motor is 1 hp; a centrifugal clutch provides a flexible coupling that prevents overloading. **Heppenstall Co.**, 4620 Hatfield St., Pittsburgh 1, Pa.

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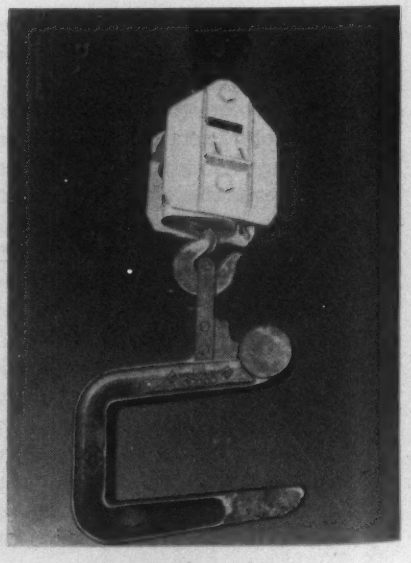

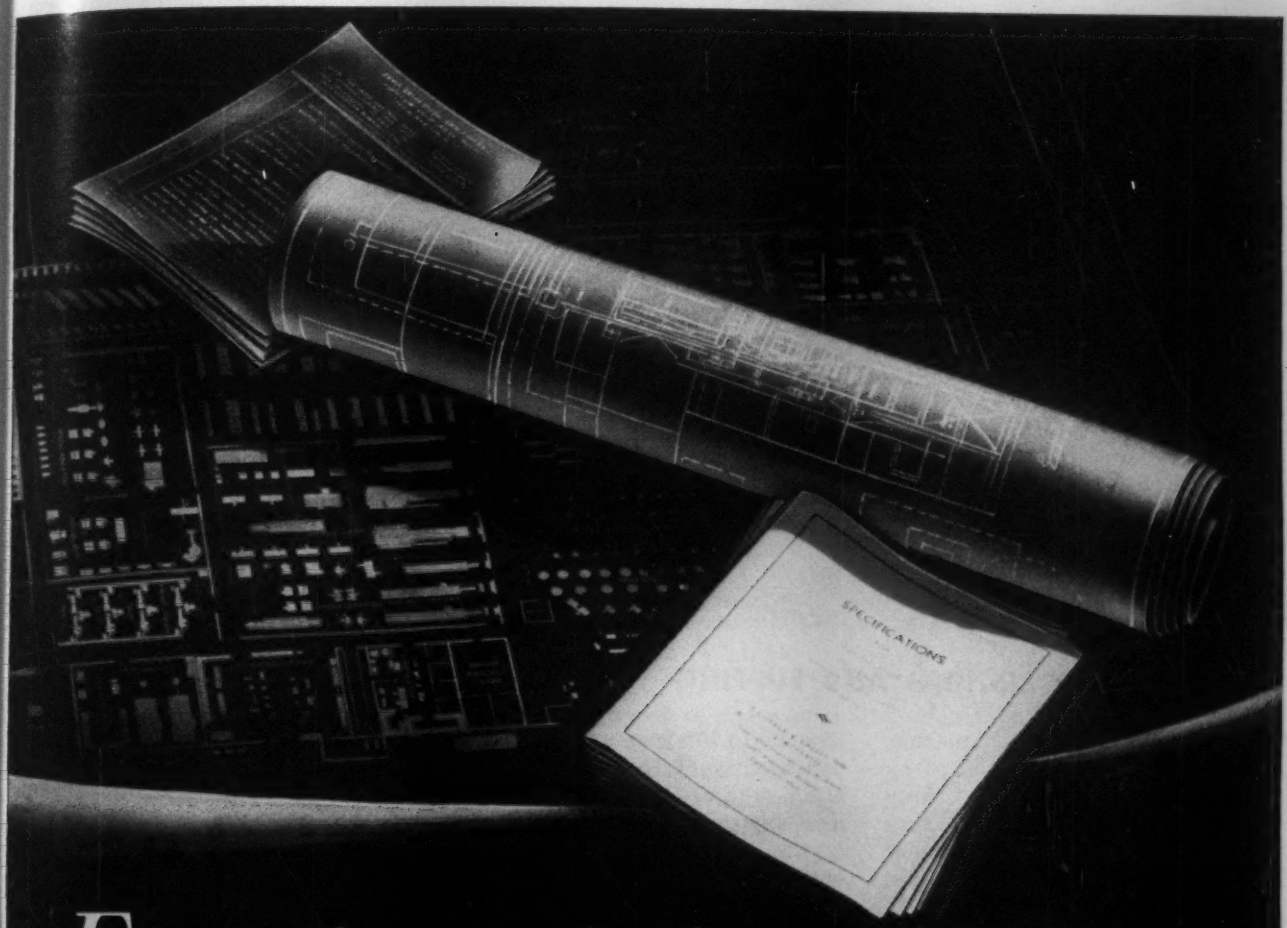

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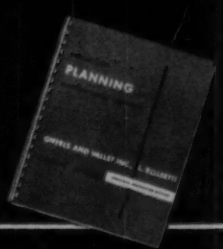
. . . IN PLANNING YOUR AUTOMATED PLANT

AUTOMATION has been engineered into Giffels & Vallet projects for many years. Although it was then not identified as Automation by name, it *did* produce automatic operations of many types. Automatic shakeouts in foundries—automatic stackers in board plants—automatic surge storage between machines—and many other applications throughout industry.

Automation is but one phase of the comprehensive planning and engineering services provided by Giffels & Vallet. Rubber, Plastics, Metalworking and Cement—these are but a few of the widely diversified industries Giffels & Vallet is serving. These services are discussed in a special Planning Brochure, and a copy will be mailed upon request.



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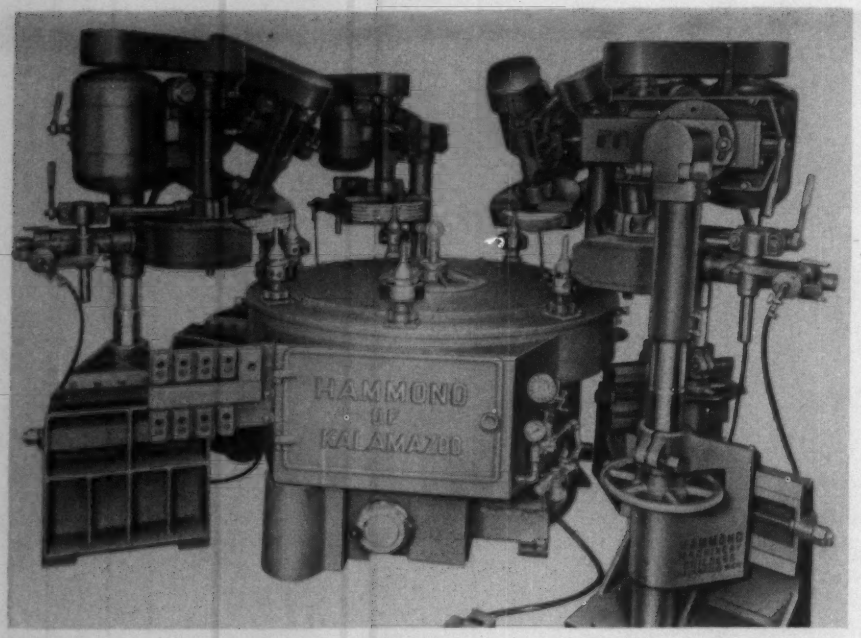

AUTOMATIC POLISHING AND BUFFING

This rotary automatic indexing machine grinds, polishes, buffs, or deburrs, is available with three sizes indexing table or as a continuous table unit. Illustrated machine has six head and stand units, a 62-in. OD indexing turret, and is 42 in. high. It operates on a constant high speed index movement of one second and has an adjustable dwell period. Table is locked in each index position by a tapered lock bolt, and a safety foot control permits operator to hold table at dwell position. Work spindles are driven by a ¾-hp motor at variable speeds from 15 to 45, or from 50 to 150 rpm, and operate independently of the indexing operation. Six of the seven work spindles support and rotate the work at the wheel station, and the seventh is located at the operator's loading and unloading station. This spindle does not revolve, but is stopped and held by a spring tensioned brake. Brake will start spindle's rotation as it is indexed into the moving table chain. Production range is infinitely variable from 150 to 1700 indexes per hour. **Hammond Machinery Builders, Inc.**, 1650 Douglas, Kalamazoo, Mich.

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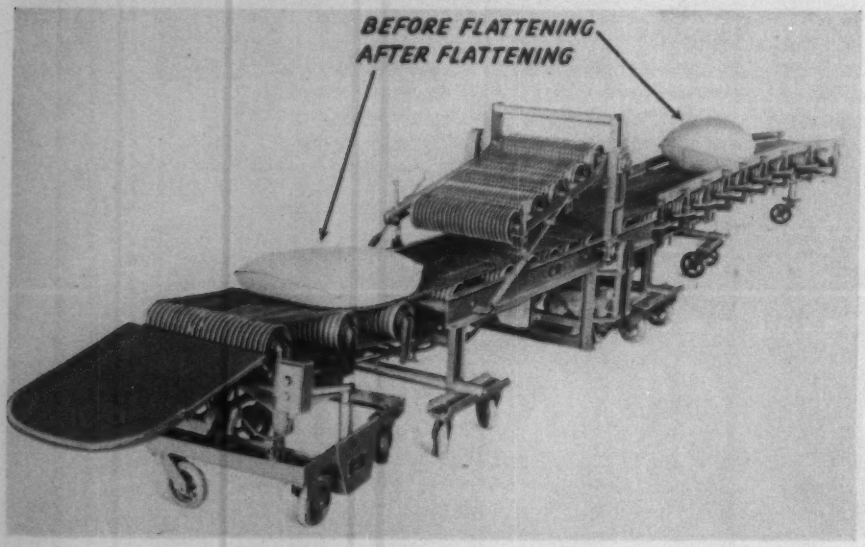
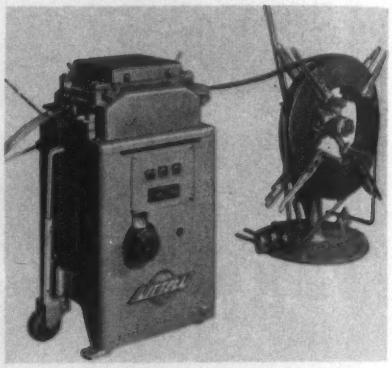
UNLOADER AND BAG FLATTENER



STOCK STRAIGHTENER

Variable speed straightening machine is designed for handling of ferrous and non-ferrous stock and has 17 power driven straightening rolls. Thin coil stock travels through the straightening rolls to have curvature removed, ready for automatic feeding to the press. Curvatures in flat parts caused by stamping operations are also effectively removed by the stock straightener. Parts up to 3/32-in. thick are straightened when they pass through the 17 power driven rolls on ½-in. centers. Among the flat-surfaced, thin metal parts which the machine straightens are contact springs, condenser plates, radio and television parts, adding and calculating machine parts. **F. J. Littell Machine Co.**, 4127 N. Ravenswood Ave., Chicago 13, Ill.



Circle No. **4** *on Reply Card*

Combination box car-truck unloader and bag-flattener can be engineered to suit customer's specifications. In the basic operation, the unloader carries bags on a flexible spring conveyor through a hugger boom section which compactly flattens each bag for storage in minimum space. Conveyor can be supplied in any length. Both unloader and flattener are powered by a 1½-hp Gearmotor. Unit runs at a speed of 120 rpm. delivers 1000 bags per hour. Side rails on the conveyor steer bags into the flattener. Hydraulic jack at the discharge end of the conveyor raises and lowers bags for loading on pallets. **Flexoveyor Mfg. Co.**, 1220 S. Acoma St., Denver 19, Col.

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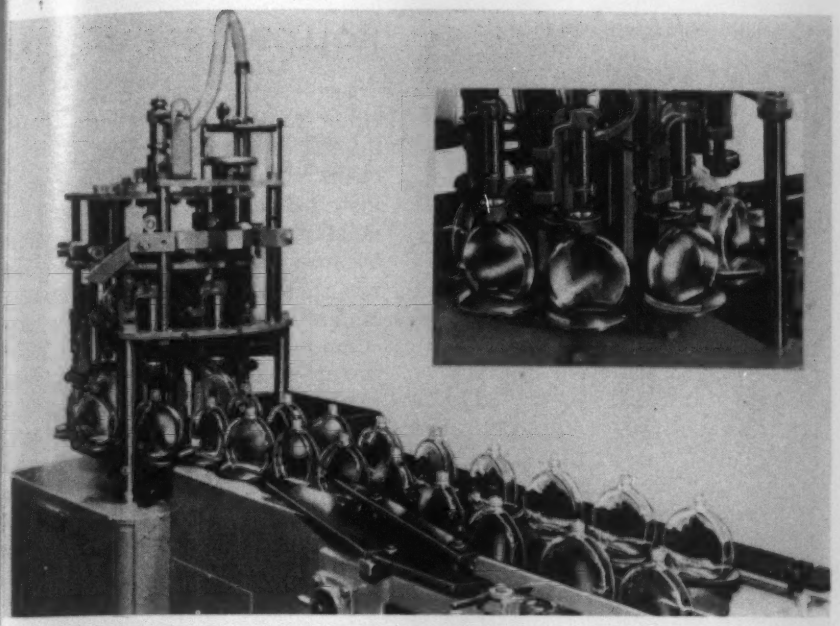

FILLING MACHINE WITH UNIVERSAL FEED

New feed arrangement in a liquid filling machine permits any shape or size container to be filled without changing the feed setup. Equipment is designed particularly for liquid products such as perfumes and toilet preparations which are packaged in a variety of containers. Operation is fully automatic regardless of container's shape or length of the production run. Feed arrangement consists of a series of flat plates mounted on a chain. Containers are fed onto these plates and carried under the filling nozzles by the moving chain. Plates are permanently synchronized with the nozzles. Containers may range in size from fractional to 16 oz, and as many as 75 can be handled per minute. **MRM Co., Inc.,** 191 Berry St., Brooklyn 11, N. Y.

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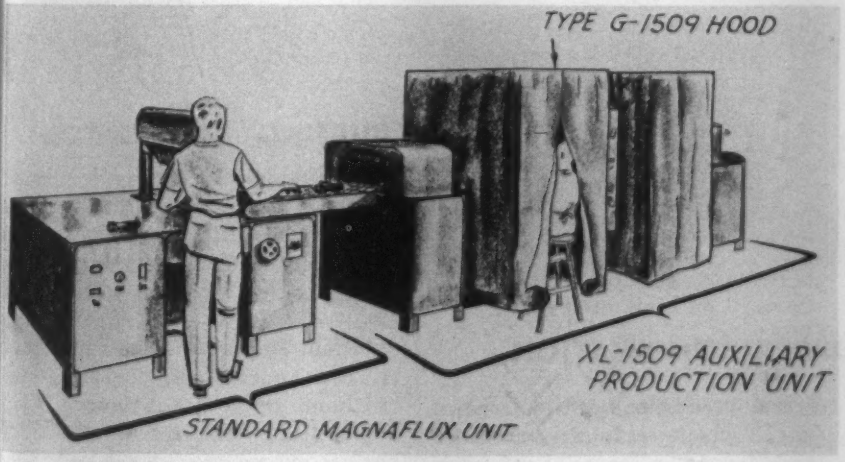

CONVEYORIZED INSPECTION UNIT

Semi-automatic conveyor system increases volume industrial inspection rates at low cost by utilizing existing facilities without obsoleting other equipment. Conveyorized units work in conjunction with standard units. One operator can supply two or four inspectors, doubling the production rate of the standard unit. Auxiliary unit not only increases inspection speed and efficiency but smooths out work flow. Operator of standard unit magnetizes the workpiece and places it on conveyor which carries it through a bath application to the inspectors who remove unacceptable parts. Piece is then demagnetized. Conveyor is stainless steel mesh, runs 10 to 40 fpm, and can carry load of 15 lb per lin ft. Inspection booth accommodates two inspectors and contains ventilating fan, standard white and black (near ultra-violet) lights. Magnaglo hood over booth is light and fireproof canvas. **Magnaflux Corp.,** 7300 W. Lawrence Ave., Chicago 31, Ill.

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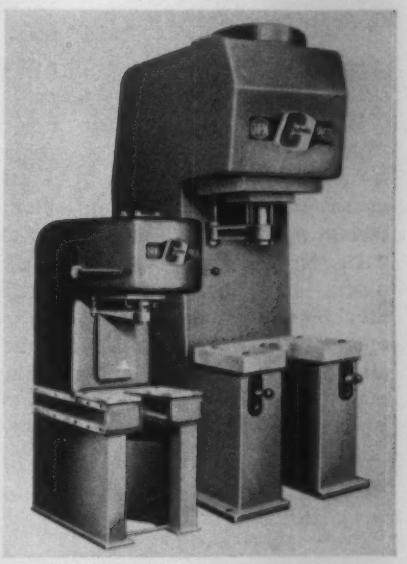

C-FRAME PRESSES

High speed differential circuits and inching controls which allow the press operator to "inch" the ram downward or upward while setting dies are among the features of a new line of oil hydraulic C-frame presses. Line includes eleven sizes—2, 5, 10, 15, 25, 35, 50, 75, 100, 150, and 200-ton models. Operating controls available include single or dual safety operating levers, electric pushbutton, foot switch, foot pedal and other standard types. Production tooling accessories available are standard bolsters, benches, bed extensions, straightening fixtures, hydraulic knockouts and die cushions. **Hydraulic Press Mfg. Co.,** Mount Gilead, O.

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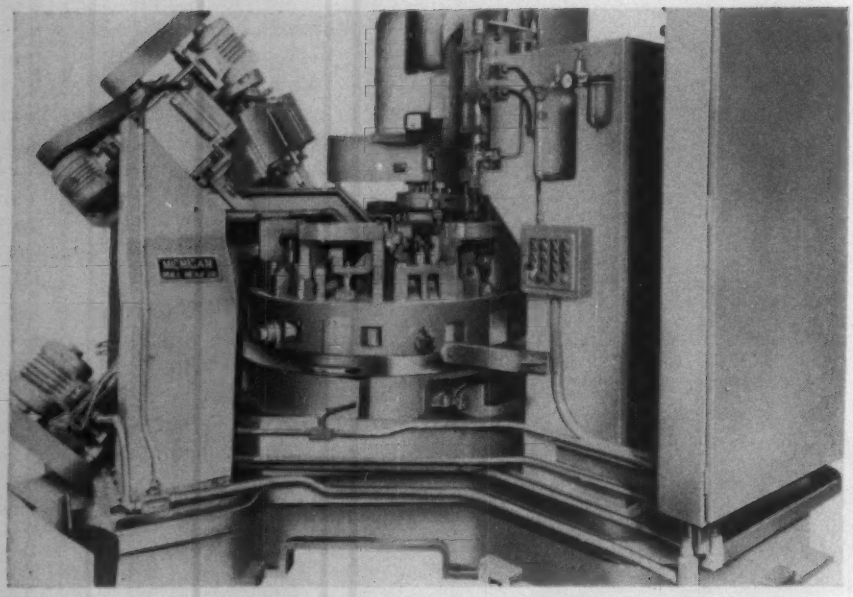

ANGULAR DRILLING IN SPECIAL PROCESSOR

Water pump bodies for a V-8 engine are processed by a special transfer type machine. Standard operations include drilling, chamfering, spot facing, and tapping on both top and bottom of the workpiece. In addition, machine drills all the angular holes in the piece by means of a two-position, hydraulically operated fixture and angular mounted units. Built around a standard Hydro-20 column assembly, the machine has a special base and special risers for the horizontal and angular units. All tapping is performed by standard tapping units with individual lead screws. Hydraulic index table is 60 in., and production rate is 120 pieces per hour. **Michigan Drill Head Co.**, Detroit 34, Mich.

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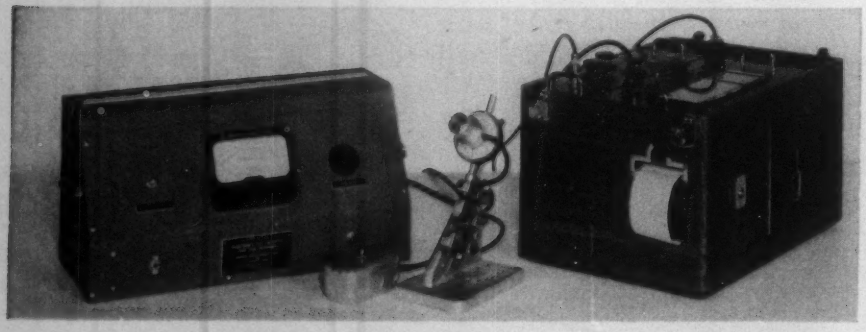

DIAL INDICATOR, SIZE RECORDER COMBINATION

Combined mechanical and electronic units will give three simultaneous readings on a tested piece —a mechanical dial for the machine operation, a meter reading to verify the recorder reading, and a permanent tape record. Piece is inserted into a conventional Johnson thread comparator (center) which measures it mechanically on a dial indicator. Dial contains a potentiometer. Reading is transferred electronically to a control (left) which actuates recorder (right). After insertion of piece into comparator, the switch button beside it must be pressed to actuate the recorder. Time cycle will advance tape automatically. Recorder can be located at a distance from other equipment if convenient. **Johnson Gage Co.**, Bloomfield, Conn.

Circle No. **10** *on Reply Card*

HOLLOW CORE MACHINE

Two-station core making machine finishes cores without the use of separate dryers or core ovens. This new machine can be installed as an integral unit in molding machine production lines because cores are ready to use when removed from core boxes. Hollow cores made by the machine are claimed to permit faster, easier shakeout, eliminate venting problems and assure closer tolerances and more uniform castings. Model 10 is equipped with twin ovens and twin core box mounts, pivoted to swing in a 180 degree arc between the ovens and fill head located in center of the machine. Machine will accommodate core boxes up to 10 by 10 by 6 inches in size and will make finished cores in a 45-second cycle. **Spo, Inc.**, 6570 Grand Division Ave., Cleveland 25, O.

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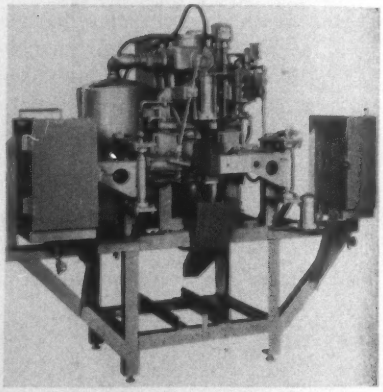

BUFFING APPLICATOR

An automatic buffing compound applicator can be installed on all types of buffing machines from simple lathes to multi-operation automatics. It can be installed in any position with no effect on operation, and is so lightweight that it can be used on floating heads without disturbing balance. Bars up to 10-in. wide and 2-in. thick can be accommodated. Machine is able to feed in any number of strokes per minute, applying compound only when required, i.e., it will apply compound only during buffing cycle and will withdraw while work changes stations. As many as eight applicators operate simultaneously from a single controlling valve. Rate of feed is adjustable

from 0.0015 to 0.015-in. per stroke. All operating parts are covered to seal out dirt and compound, and construction is of lightweight aluminum. **George L. Nankervis Co.**, 19255 West Davison, Detroit 23. Mich.

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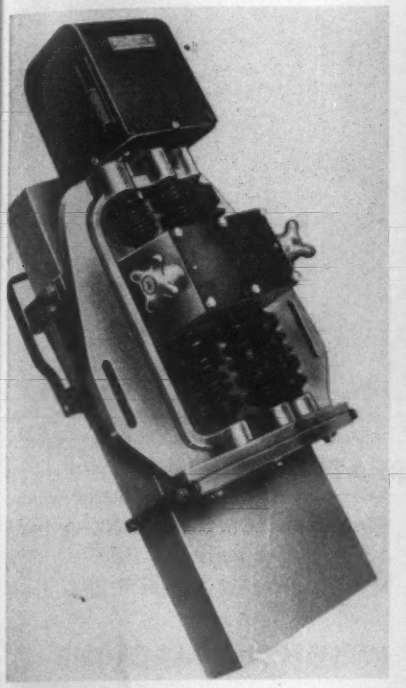
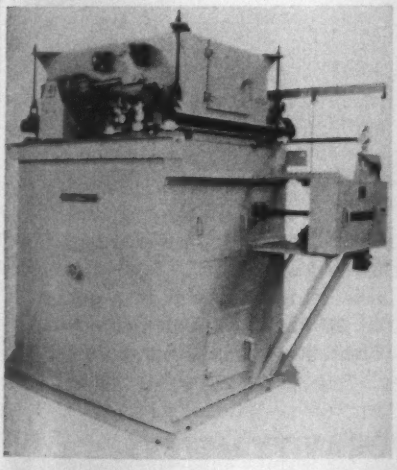
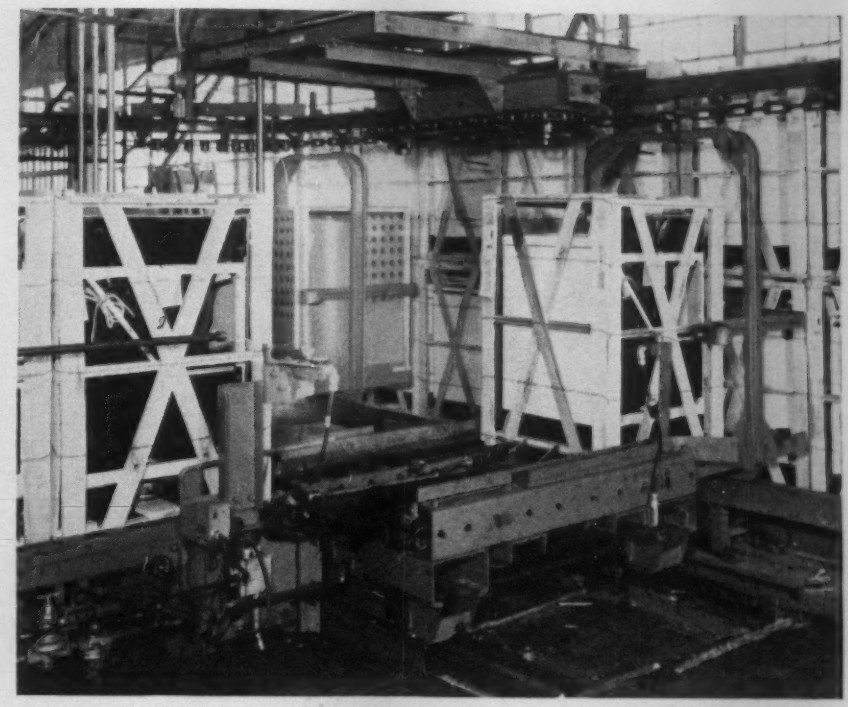


TONNAGE WEIGHER

Industrial batching scale is specially designed for weighing hot materials and ores in high tonnage



quantities. Automatic scale features heavy-duty construction, a 25 cu ft weigh hopper, a dust-tight housing covering the entire scale, separately housed controls, and ⅜-



AUTOMATIC TRANSFER

from assembly line to moving delivery line

The overhead conveyor shown above picks up crated appliances from multiple assembly lines and delivers them to storage and shipping. Transfer of the crated machines from assembly line to delivery conveyor is completely automatic.

The transfer device was conceived, engineered and built by Mechanical Handling Systems. Limit switches discover an approaching empty carrier on the overhead conveyor, activate the transfer carriage which accepts a crated appliance and moves it sideways at the overhead conveyor speed and forward onto the empty carrier.

This is another example of automatic handling developed by MHS to cut costs, to speed production and to protect the product from damage. *It is successful automation.*

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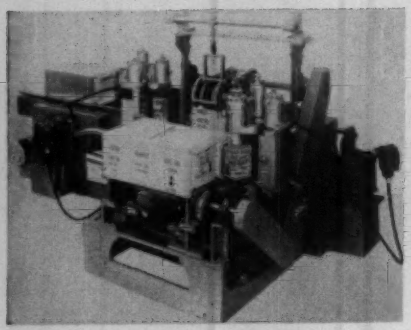
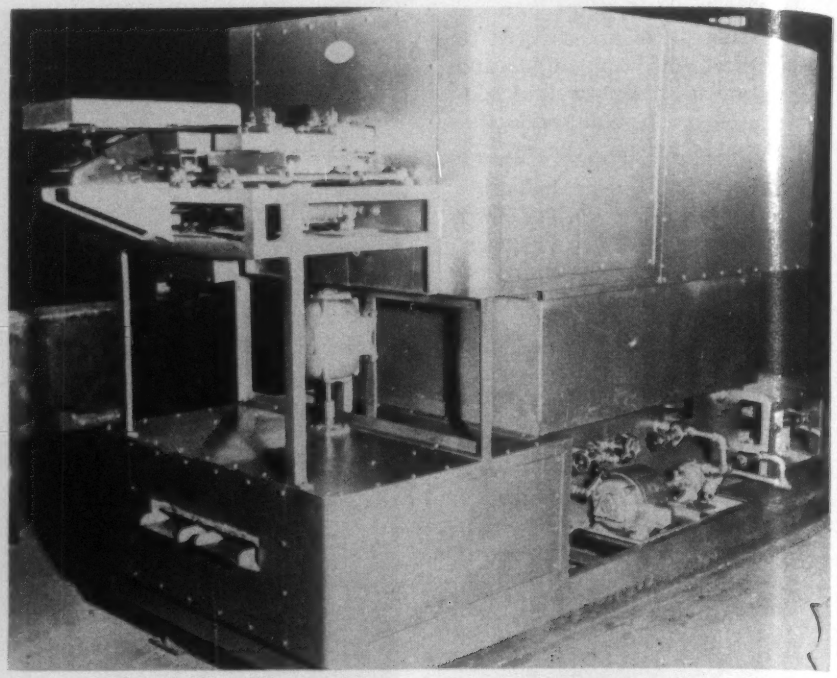
in. steel plate contacting the material being weighed. Scale will handle ores, coal, grain, stone, gravel, sand, plastics, chemicals, or any granular, small lumpy material. Machine has demonstrated accuracies of 0.1 per cent at operating speeds of five weighings per minute. **Richardson Scale Co.**, Clifton, N. J.

Circle No. **13** *on Reply Card*





CRATE MARKING

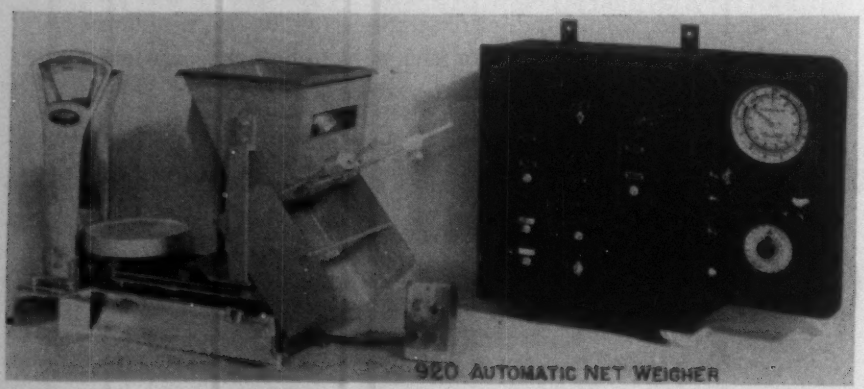
Machine which imprints the top, ends and a side of wood wire-bound crates on the production line has been added to the line of "Markoprinter" imprinters. Machine is engineered to produce high-quality markings at fast production speeds. Special mechanisms are built into the unit to compensate for the very lightweight construction of the crate, the recessed ends, the wavy nonuniform surface and the interference of wires surrounding the container. The unit can be set up on a production line where it receives the cases from a packing line conveyor, prints them automatically and discharges them on to the next station. **Adolph Gottscho, Inc.**, Hillside 5, N. J.

Circle No. **14** *on Reply Card*

PRODUCTION LINE HEAT TREATMENT

Heat treatment unit can be incorporated into a production line to take parts from a conveyor and deliver them to a discharge conveyor to give completely automatic service. Machine will heat treat, carburize, and dry-cyanide small or large parts which do not have to be handled on trays. Machine adapts to individual running of one to four different parts simultaneously at individual cycles. Either gas or electricity can be used to fire, and temperature in the hardening furnace will run as high as 1750° F, and in the draw furnace 1350° F. Machine consists of an atmosphere type hardening furnace, an oil or water quench tank, a washing machine, and an open or atmosphere draw furnace. Production capacity is from 75 to 500 lb. **Ferguson Equipment Corp.**, 21st St. & Penn Ave., Pittsburgh 22, Pa.

Circle No. **15** *on Reply Card*



WEIGHING MACHINE

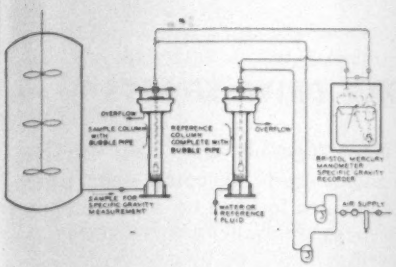
Load discharge timer and counter are major features of this automatic net weighing machine for all types of free-flowing materials. Vibratory feeder feeds the weigher until a predetermined amount is in the weigh bucket. Bucket, however, will not discharge contents until a preset time interval elapses. Counter records the number of loads weighed, shuts operation off when correct number of loads have been made. Manual control by pushbutton is possible whenever desired in the cycle. Control rheostats provide infinite adjustment of both fast and slow rates of feed to weigh bucket. Capacities available range from a few ounces to 25 lb. **Exact Weight Scale Co.**, 944 West 5th Ave., Columbus, Ohio.

Circle No. **16** *on Reply Card*

GRAVITY METERS

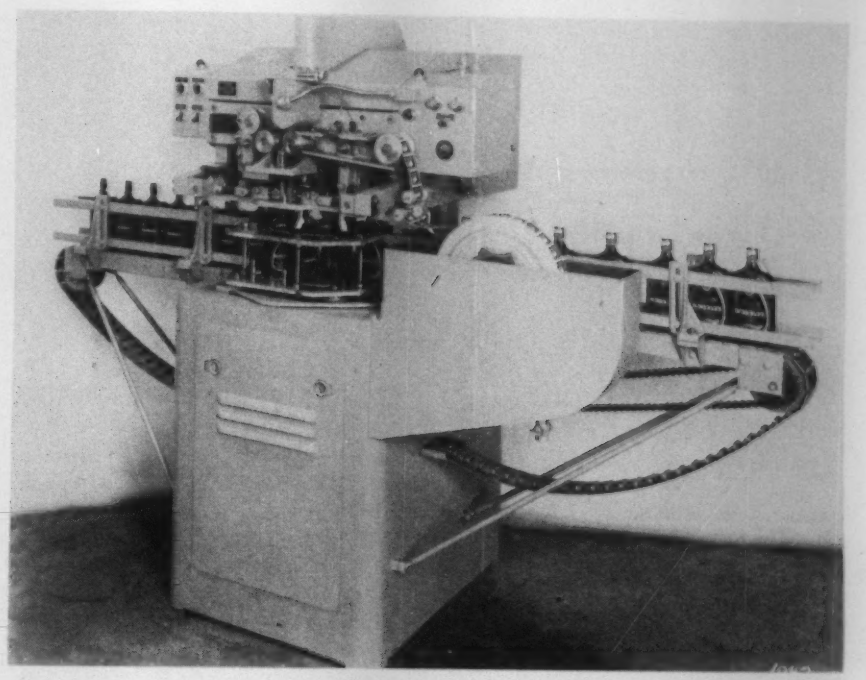
New line of meters operates by comparing the pressure necessary to displace a given head of the sample liquid in a bubbler pipe with the pressure necessary to displace an equivalent head of water.

Gravity Meters can be used for any liquid solution, mixture or slurry into which a bubbler pipe can be inserted. Instruments used for this purpose can be calibrated directly in terms of specific gravity, Twaddell units or degrees Baume. Meters use a Mercury



meter body, with or without counterpose and a standard Bristol recorder, which can also be equipped to provide automatic control of the specific gravity, in any of five control models. **Bristol Co.**, Waterbury, Conn.

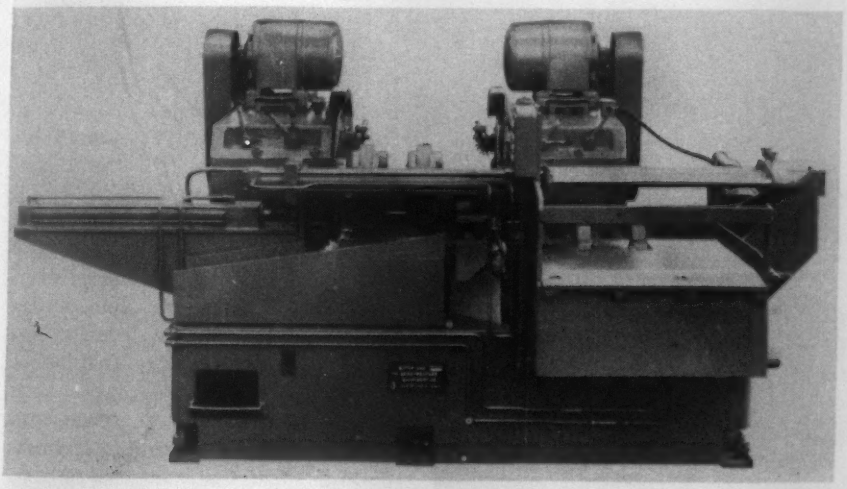
Circle No. **17** *on Reply Card*



AUTOMATIC CELLULOSE BANDING OF BOTTLES

Cellulose banding is automated in a compact machine which turns out uniformly and precisely banded bottles. Bottles may be any size or shape up to 3¾-in. in diameter, and bands are available in a large range of styles and sizes. Cellulose banding, in roll form, feeds into position for cutting over the bottle, which is indexed by a starwheel feed to receive the band. Combination mechanical and vacuum action opens band which is then stripped off a plunger onto the bottle neck and cap. Quick changeover to various sizes bottles and bands is accomplished by simple attachments. Only attention required of operator is for renewal of cellulose banding roll. **Economic Machinery Co., Geo. D. Meyer Mfg. Co.**, Worcester, Mass.

Circle No. **19** *on Reply Card*



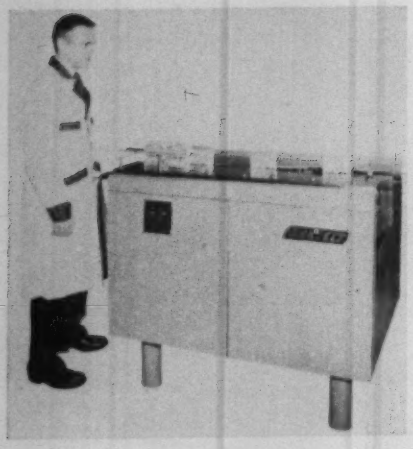
DUPLEX CROPPING SAWING MACHINE

Two sawing heads, right and left hand, are arranged for automatic simultaneous cropping of both ends of an 8-in. shell forging in this machine. Heads have nine spindle speeds, multiple disc clutch to engage spindle drive, and a self-contained lubrication system. Heavy steel base is stress-relieved, normalized with coolant sump, and has ample chip compartments. Forgings are magazine loaded from conveyor and passed singly into the loading position by an escape mechanism. Hydraulically actuated loading ram pushes shell into clamping station where it is positively located by a hydraulically operating locating rod. Automatic cycle continues as long as pieces remain in the loader. **Motch & Merryweather Co.**, Penton Bldg., Cleveland 13, Ohio.

Circle No. **18** *on Reply Card*

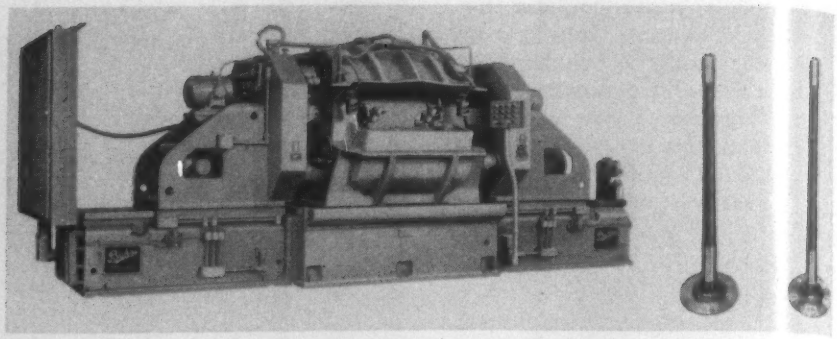
CHECKWEIGHER

New machines in line of packaging equipment detect weight differential of 1/60-oz at speeds up to 130 per minute. Machines are designed to be incorporated as an integrated in-line unit of a continuous packaging system. These checkweighers are capable of handling packages up to 4½ by 7¾-inch base size, and cans or glass jars up to 5⅛-inch diameter. The normal weight range is between ¼-oz and 10 lb. Cartons are handled with a pusher type loader; cans or jars by a worm type



loader. Machine uses an accurate weighing mechanism and a simplified, plug in type electrical unit working with a controlled motion scale. Overweights or underweights are by-passed automatically by deflector fingers to parallel conveyors for reprocessing. **Bartelt Engineering Co.**, Rockford, Ill.

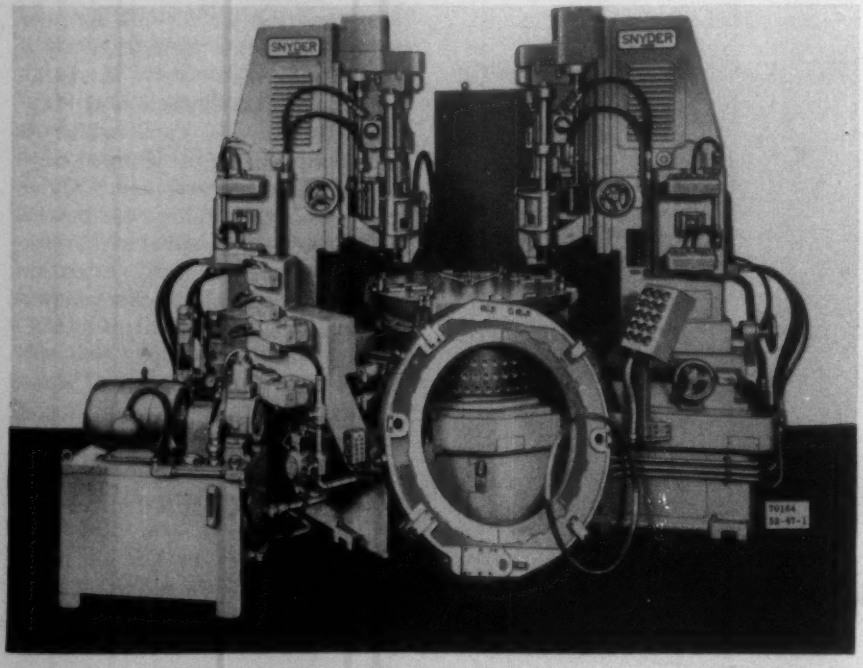
Circle No. **20** *on Reply Card*



TRANSFER MACHINE FOR AXLE DRIVE SHAFTS

Six-station, two-way trunnion machine performs 36 operations on two rear axle drive shafts at one time. Holes are drilled, and both sides of holes are chamfered and tapped at a rate of 328 pieces per hour. Parts are loaded, two at a time, at each station and are clamped and unclamped automatically by hydraulic fixtures. Cluster heads are incorporated in a master gear box. All parts are interchangeable and held to tolerances, and all component assemblies are located by precision-bored dowels to insure perfect alignment. Multiple heads are of ball-bearing construction with shaved gears and broached-and-splined drives. Lead-screw tapping spindles have precision-ground and hard chrome plated threads. **Buhr Machine Tool Co.**, Ann Arbor, Mich.

Circle No. **21** *on Reply Card*



DRILLS, REAMS IRREGULAR HOLES

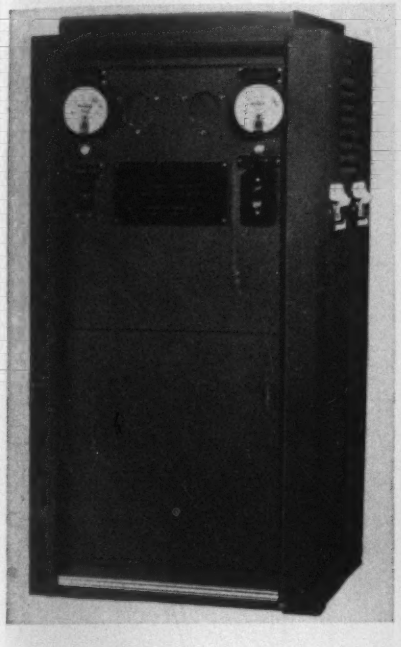
Designed to drill and ream holes in rims of outer shroud spacers for jet engines, an automatic multi-station machine can adapt to process other similar parts. Only manual operation is the clamping of the workpiece, entire work cycle is automatic. Workpiece is a thin-walled ring of stainless steel to be drilled and reamed on both sides. Spacing between holes varies from part to part but all hole spacing resolves to multiples of a specific angle.

A fixture mounted on an index table (shown in front of index table in photo) is flanked by hydraulic drill units which are adjustable to permit positioning for different size parts. Workpiece is clamped in jigs, located over pins, then clamped to fixture. The index table produces minimum indexes of the basic hole spacing angle by means of four shot pins and four rows of shot pin holes. A control drum governs the index, selects the proper shot pin for locating the table and signals the drilling or reaming unit at the proper time. This drum consists of seven rows of pins spaced around a cylinder making electrical contacts to actuate sensitive relays which control the operation of the machine. Each individual hole pattern requires a separate drum. While the illustrated machine is tooled up for processing 12 individual parts, a change of the shot pin rows and control drum can make machining of other similar parts feasible. Two workpieces an hour at 80 per cent efficiency can be processed.

Spindle speed varies from 640 to 2240 rpm, feeds vary from 1.75 to 12-in. per minute. Stroke is 8-in. Spindles and table are hydrau-

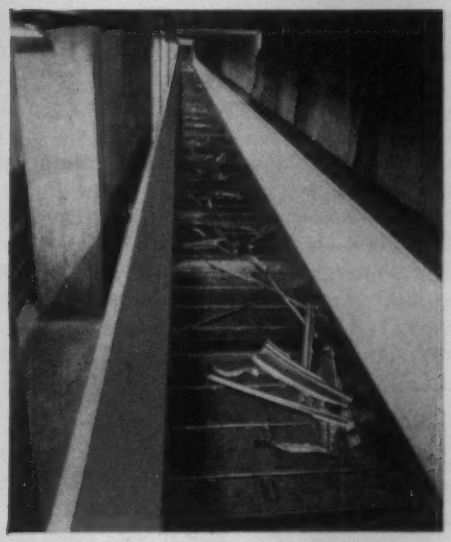
lically powered, and spindles are driven by 1 hp motors. Hydraulic pump is driven by a 7½-hp motor. Entire operation is electrically interlocked to protect both operator and machine. Floor space required is 133 x 128-in., including hydraulic tank, coolant tank and electrical panel. Coolant supply is in separate tank at rear of machine and has its own ½-hp motor. A central lubrication system is hand-operated. **Snyder Tool & Engineering Co.**, 3400 E. Lafayette Ave., Detroit 7, Mich.

Circle No. **22** *on Reply Card*



ULTRASONIC CLEANING

Heavy duty, ultrasonic power generator speeds cleaning and degreasing of parts made of metal, rubber, plastics, glass, and ceramics. Generator's 2000 w output is fed into a barium titanate transducer at 100,000 cycles per second. Transducer, which is immersed in the cleaning solvent, converts the 100,000 cycles per second radio frequency into mechanical vibrations which set up a violent agitation in the solvent, shaking dirt and grease loose almost instantly. A single 2000 w generator can drive a transducer with a surface area of 70 to 100 sq in., or several smaller transducers with the same total area. Transducers can be placed in a tank of any size, and large pieces of equipment can be cleaned ultra-



THIS 1200 FT. PLANET CONVEYOR moves 20 tons of scrap per hour!

Planet apron conveyor moving through tunnel beneath trim presses.

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Over 20 **tons** of scrap per hour drop on a Planet hinged-pan apron conveyor as it moves through a tunnel under the presses. Moving to an automatic baler, the scrap is compressed into 2' cubes. Then the baled scrap moves on a Planet pusher bar conveyor direct to the waiting railroad cars. A simple clutch-operated auxiliary drive assures continuity of operation.

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Because this scrap-handling system saves time and labor . . .

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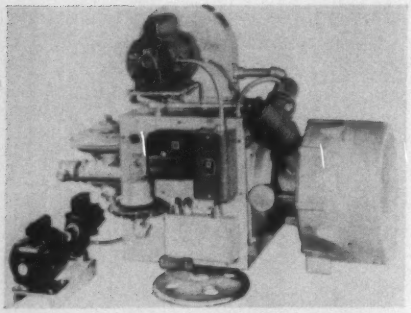
sonically by moving them over the active, focal area of the transducer. Unit provides an economical source of ultrasonic power for many other laboratory and production processes involving liquids such as emulsification, dispersion, and acceleration of chemical reactions. Generator is cooled by forced air, is 43 x 23 x 18½-in., and weighs approximately 350 lb. **Branson Ultrasonic Co., Branson Instruments, Inc.,** 430 Fairfield Ave., Stamford, Conn.

Circle No. **23** *on Reply Card*

GAS-OIL BURNER

Fan-type combination gas-oil burner for firing rates up to 3,000,000 Btu, can be used with gas and light oil, oil or gas for automatic off-on firing of steamboilers, water heaters, air heaters, heating plants, and industrial ovens. Unit consists of blower, burner, oil pump with motor, built-in tuyere, air/gas mixer, safety equipment, transformers, valves, regulators, filter, piping and wiring. A snap-switch control on the side panel changes fuel automatically and sets all necessary controls in operation for the particular fuel in use. An outside mounted air switch is interconnected with fuel controls to delay opening of main fuel valve until air pressure is at full-on for complete combustion. In addition to resultant clean firing, the switch provides a safety feature in case of air supply failure and instantly cuts off fuel to the burner. Positive ignition is assured with direct, electric spark ignition for oil fuel and a gas pilot for gas. Flame failure protection is provided by electronic and flame electrode-detectors. **Eclipse Fuel Engineering Co.,** 1002 Buchanan St., Rockford, Ill.

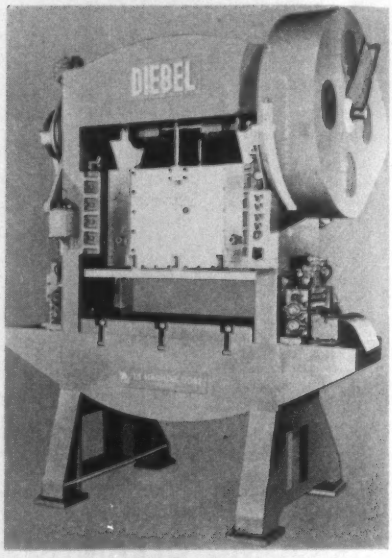


Circle No. **24** *on Reply Card*

AUTOMATIC PRESS

Among the features of the 60-ton double crank welded steel press are a cylindrical type ram for accurate alignment and air clamped feeds which prevent stock distortion and permit positive feeding. The automatic press also includes a balanced crankshaft, air counterbalances, automatic metered lubrication system, complete electrical controls, an air clutch and specially designed shock mounts. Machine is available with 30, 37 or 45-inch width between uprights and a 10 inch width of feed roll. **Di Machine Corp.,** 2701 W. Irving Park Rd., Chicago 18, Ill.

Circle No. **25** *on Reply Card*



COLLATOR

Accra-Feed, a new collating machine, assembles reports, forms, catalogs, etc., replacing five to

what article

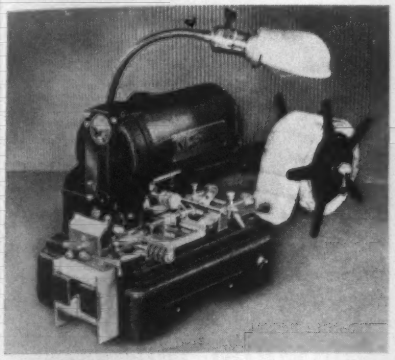
in this issue would you like to have in your file?

Just circle the page number on the reply card and we'll do the rest.

This service is free. See page 112.

six people. It compiles as many as 50 identical sets of printed matter, organizing each of 125 different pages in proper sequence at speeds up to 6000 sheets per hour. The machine shuts itself off upon completion of job. Photoelectric scanning devices automatically eliminate all unprinted pages, and an adjustable micrometer rejects double sheets. **Reproduction Products Co.,** 12790 Westwood Ave., Detroit 23, Mich.

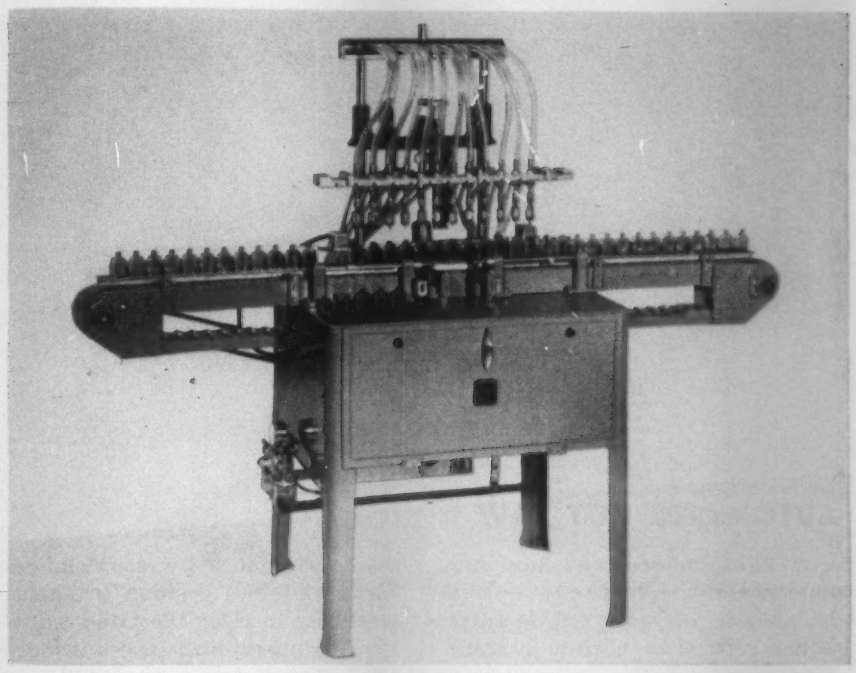
Circle No. **26** *on Reply Card*



LABEL MARKER

Inventories of preprinted tickets can be avoided by marking tickets and labels as they are needed with an automatic, easily operated label printer. Labels range in size from 1¼-sq-in. to 3 x 1⅞-in. and can be used for product identification, stock control, piecework and production control. They are available gummed or ungummed, with or without perforations and preprinted trademarks or designs. Machine automatically marks, counts, cuts, and stacks up to 144 roll-fed labels per minute. Self-stop counter stops machine when required number of tickets is printed. Hand set register permits quick change of numbers without resetting type. Automatic wheel gives consecutive or duplicate numbering, keeping all other information constant on a series of labels while changing certain numbers. Standard equipment includes type chase, complete assortment of type, ink, lubricating oil, and flexible-arm lamp. Printer operates on 110 v ac, 60-cycle motor. **Soabar Co.,** 5815 Erdrick St., Philadelphia 24, Pa.

Circle No. **27** *on Reply Card*



AUTOMATIC BOTTLE FILLER

Bottles ranging in size from ½-oz to 1 gal can be filled automatically at a rate of 180 bottles per minute. Machine requires no operator, and features stand-still filling to reduce danger to filling spouts or bottles, and to eliminate agitation of the liquid. Changing from one size bottle to another is rapid. **Perl Machine Mfg. Co.,** 68 Jay St., Brooklyn 1, N. Y.

Circle No. **28** *on Reply Card*

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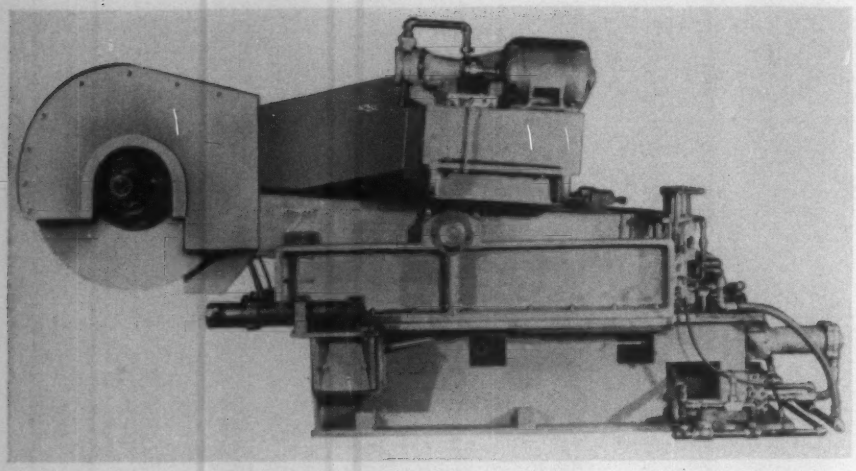
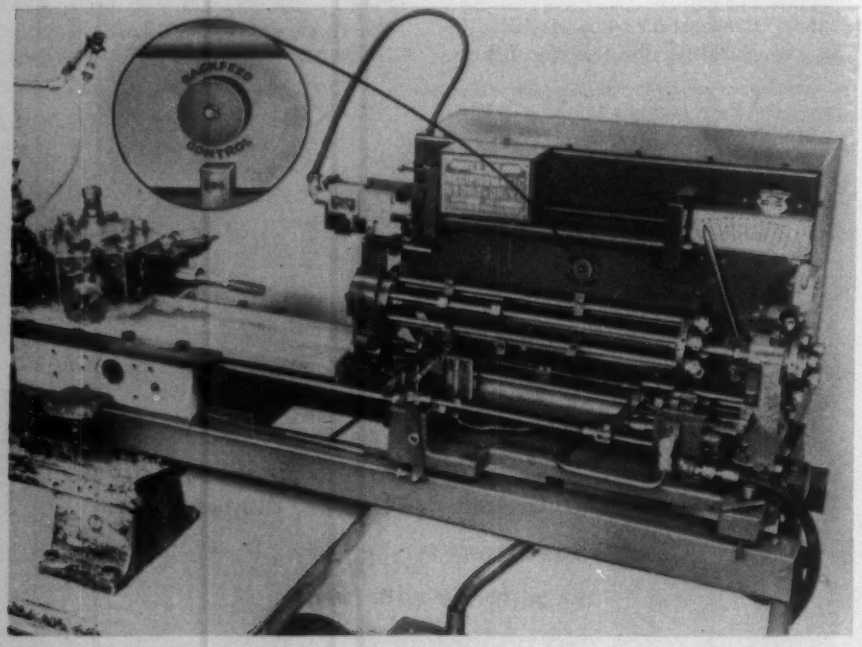


AUTOMATIC HOT SAW

A 48-in. crosscut and drop saw automatically cuts two 7 x 7-in. billets side by side, and features either vertical or horizontal blade feed. Hydraulically operated, saw has feedback controls to utilize maximum 150 hp constantly regardless of thickness of material being cut. When crosscutting, the blade lifts out of hot zone and returns to initial position to enable workmen to clear the table quickly. Peripheral blade speed is more than 20,000 fpm. **York-Gillespie Mfg. Co.**, 39th St. and Allegheny Valley Railroad, Pittsburgh 1, Pa.

Circle No. **29** *on Reply Card*



TURRET BACKFEED ON HYDRAULIC DRIVE

Hydraulic drive for turret lathes features backfeed on any or all turret stations. Production is consequently speeded by possibility of many cross slide operations on the turret. For instance, ID of a piece may be machined where tool marks are not permissible. Also, it is possible to make a rough cut going in and a finished cut coming out. Infeed and backfeed rates are adjusted independently of each other for maximum flexibility. Complete machining cycle on the hex is automatic when this hydraulic drive is applied to any ram type turret lathe. **Lincoln Industries,** 1123 South 7th Street, Minneapolis 4, Minn.

Circle No. **30** *on Reply Card*

DUST, FUME COLLECTOR

Cylindrical drum with series of cones and baffles has cyclonic washing action and turbulence; uses water to filter dust and fume laden air. **Van-Truer Co., Inc.,** 12600 Beech Rd., Detroit 23, Mich.

Circle No. **31** *on Reply Card*

DRILLING MACHINE

Machine consisting of four self-contained hydraulic feed drill units is designed to process cast iron tractor transmission cases. **Snyder Tool & Engineering Co.,** 3400 E. Lafayette, Detroit 7, Mich.

Circle No. **32** *on Reply Card*

WET TYPE GRINDER

Machine is designed to produce straight bevel Coniflex gear with high accuracy. **Gleason Works,** 1000 University Ave., Rochester 3, N. Y.

Circle No. **33** *on Reply Card*

INDUSTRIAL TRUCKS

Gas powered, electric transmission trucks are designed to handle bigger pallet loads. **Automatic Transportation Co.,** 149 W. 87th St., Chicago, Ill.

Circle No. **34** *on Reply Card*

LIFTING TABLE

Conveyorized elevating table is designed to handle long sheets of material being fed into a shearing operation, a blanking press or press brake. **Union Tool Corp.,** Warsaw, Ind.

Circle No. **35** *on Reply Card*

AUTOMATIC LATHE

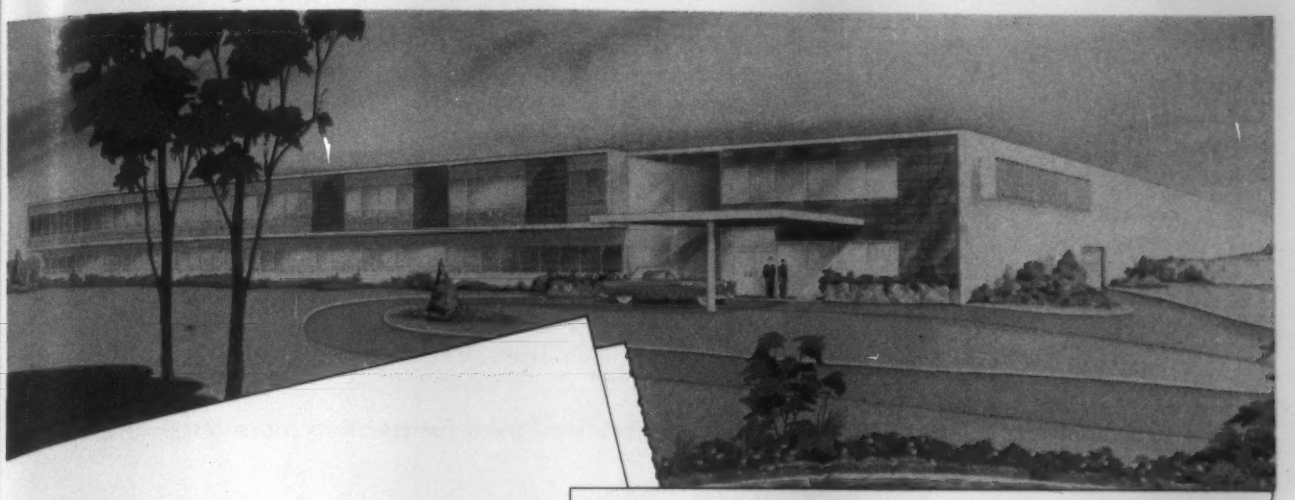
Machine is designed for roughing and finishing of a cast magnesium alloy jet engine housing. **Hydra-Feed Machine Tool Corp.,** Ferndale, Mich.

Circle No. **36** *on Reply Card*

ELECTRIC FORK TRUCK

Side loading and unloading attachment on truck makes it possible to transfer long loads directly into storage racks with a minimum of truck maneuvering. **Lewis - Shepard Products, Inc.,** Watertown, Mass.

Circle No. **37** *on Reply Card*



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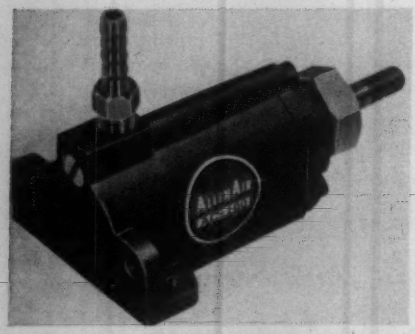


Spring Return Air Clamp

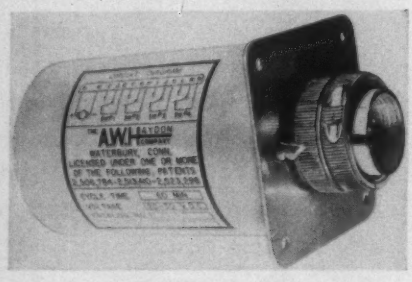
Furnished with cast bosses for either vertical or horizontal mounting, a new spring return air clamp has 1⅛-in. bore and 1-in. stroke. Nose piece is threaded. Two ⅛-in. NPT tapped holes are set at 90° angles to each other for optional air inlet. One hole is plugged and the other is fitted with a brass barbed connector for standard ¼-in. hose. Piston rod is threaded on the front end and is of stainless steel. "O" ring seals the piston. **A. K. Allen Co.,** 57 Meserole Ave., Brooklyn 22, N. Y.

Circle No. **38** *on Reply Card*

Pulse Counter

A variable scale pulse counter can be used alone as a decimal counter with input rates up to 500 kc or as a variable scale counter with self-contained electronic reset. Used with a new sequence gater (illustrated), it provides ten direct current outputs that can be used in gating other units in a pulse test system. Counter has plug-in connections and manual adjustment for scale factors of 2 through 10. Units may be cascaded to provide any scale. Manual and electronic reset make the instrument applicable to all counting applications including preset counters, burst counters, scalers, and adders. Each count is represented visually by a neon indicator and electronically by a dc signal which allows counter to act as a sorter, pulse distributor, converter, or coding device. Input accepts and amplifies 0.1 microsecond, 25v pulses and applies them to a beam switching tube. **Electronics Instruments Div., Burroughs Corp.,** 1209 Vine St., Philadelphia, Pa.

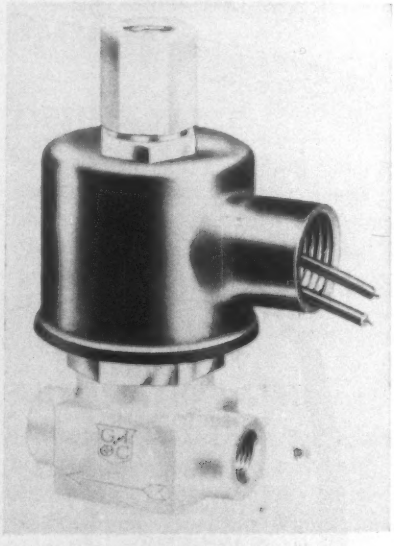
Circle No. **39** *on Reply Card*



Miniature Repeat Cycle Timer

Equally well suited for local or remote control, or for continuous duty operation a new hermetically sealed, miniaturized repeat cycle timer is driven by 50, 60, or 400 cps ac motor, or by standard or governed dc motor. DC units are equipped with radio interference filtering and a special ratchet drive to prevent damage to motor in case of reversed polarity. Intercam reduction is available to allow high speed pulsing with an extended cycle time. Reduction of as much as 960:1 can be incorporated. Suitable for all environmental conditions, the timer can be furnished with flange or three stud mounting, and with AN connector or a glass-metal header. **A. W. Haydon Co.,** 230 N. Elm St., Waterbury, Conn.

Circle No. **40** *on Reply Card*

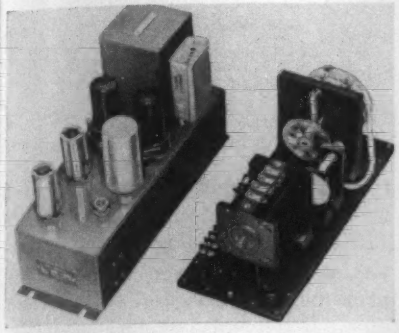


Magnetic Solenoid Valve

Midget, magnetic, 3-way solenoid valve with an axial flow outlet can handle a variety of liquids and has a complete selection of flow patterns. It is available as a normally closed 3-way, normally open 3-way, or directional flow control valve. Housing may be of brass for normal applications, or of stainless for corrosive fluids.

Solenoid cover can be rotated for convenience in installation. A soft seat closure eliminates impact noises and assures complete shut-off. Applications include use on industrial machinery, air and hydraulic cylinders, dispensing machines, and chemical processing equipment. **General Controls Co.**, 801 Allen Ave., Glendale, Calif.

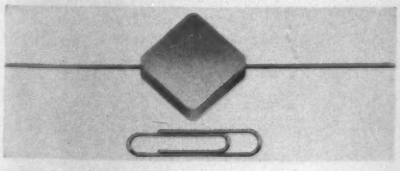
Circle No. **41** *on Reply Card*



Servo Multiplier

Designed as a building block for control equipment in automatic factories and in process control installations, this new servo multiplier consists of a servo amplifier and gear box with optional power supply and prewired rack mounting. Unit operates from 60 cycles per second line to convert dc input variable into shaft rotation. Shaft drives a precision potentiometer, which performs actual computation. Three 2-megohm summing inputs accommodate one, two, or three input variables. Overall accuracy is 0.3 per cent, full scale travel under 0.5 second. **Industrial Control Co.**, Wyandanch, L. I., N. Y.

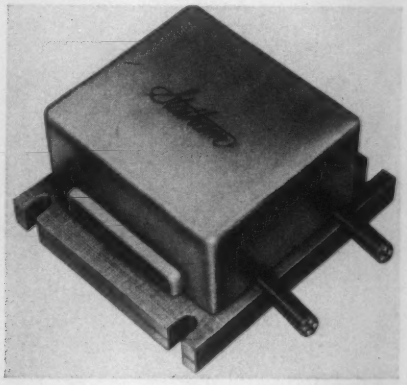
Circle No. **42** *on Reply Card*



Miniature Toroid Coil

"Postage stamp" toroid coil consists of a subminiature molybdenum permalloy toroid core and impregnated winding with a residual hole as small as 1/16-in. Epoxy plastic encases the entire coil, and tinned #20 AWG wire leads are provided. Unit is available in any inductance up to 1 Hy. Frequency range is from 1500 cycles per second to 150 kc depending upon inductance value. Ambient temperature range is from −55 to 125C. Standard model is 13/16 x 13/16 x 3/8-in., but an unencapsulated model is available with winding ends exposed for making direct connections. This model is only 5/8-in. OD and 9/32-in. thick. **Hycor Co., Inc.**, 11423 Vanowen St., North Hollywood, Calif.

Circle No. **43** *on Reply Card*



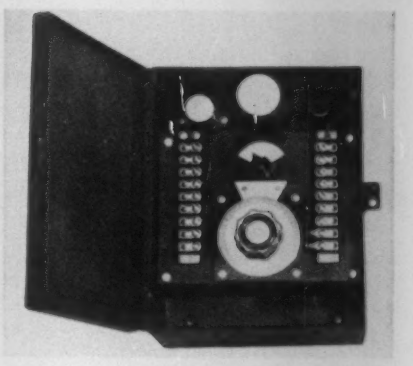
Controlled Accelerometers

Series of temperature controlled linear accelerometers is designed to operate in ranges of ±0.5 to ±15 g and to maintain constant and static characteristics within wide ambient temperature variations. An electrical heater jacket has power input as high as 20 and 30 w, which permits operation within ambient temperature range of −65 to 120°F. Transducing element is unbonded resistance strain gage. Model illustrated is offered in ranges from ±1 to ±15 g. **Statham Laboratories, Inc.**, 12401 W. Olympic Blvd., Los Angeles 64, Calif.

Circle No. **44** *on Reply Card*

General Purpose Timer

Accuracy of 1 per cent is reported in interval timing, timed delay, repeat cycling, programming, or pulsing by a new general purpose electronic timer. Unit's unique circuit design enables it to maintain same accuracy over line voltage variations from 90 to 135 v. Timer is particularly applicable to industrial processes where such



variations may be present and would normally impair accurate timing. These include process timing, sequence control of automated equipment, induction heating equipment, conveyors, machine tools, injection molding machines, packaging and filling machinery. Three time ranges available are 0.1 to 1 second, 1 to 10 seconds, and 10 to 100 seconds. Additional features are a direct reading time dial, and two single-pole, double-throw load contacts with 8 amp rating. **Ferrara, Inc.**, Dept. D-2 8106 W. Nine Mile Rd., Oak Park 37, Mich.

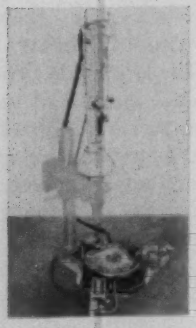
Circle No. **45** *on Reply Card*

Miniature DC Relay

Compact and rugged dc relay exceeds Air Force electrical and mechanical requirements, is designed for use in circuit applications having severe service conditions. Contacts are immune to dust, corrosion, and moisture because unit is evacuated, filled with inert gas, and sealed off. Pure silver contacts are 6-pole, double-throw, and rating is 2 amp at 26.5 v dc resistive load with 72 milliwatts input sen-

sitivity. Resistance is 0.03 ohm maximum. Ambient temperature range is from −65 to 125° C. Unit operates under 100 g shock, and 10 to 500 cycle vibration at over 30 g amplitude. Terminals may be closed loop, spade, plug-in, or AN connector. Relay can be mounted in any position. **Deltronic Corp.,** 9010 Bellanca Ave., Los Angeles 45, Calif.

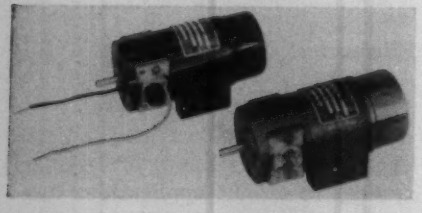
Circle No. **46** *on Reply Card*



Drill Feed Control Valve

A drill feed control valve automatically synchronizes indexing of rotary table with the drill feed, eliminating tool breakage and permitting use of coolants without fear of shock and fire. Adjustments can be made on the drill feed during the drilling cycle without affecting the rotary table because table indexes only upon completion of the drill feed cycle. This synchronizing control valve will adapt to most conventional drill presses and to many rotary tables currently on the market. **Machine Tool Div., General Pacific Corp.,** 1501-15 E. Washington Blvd., Los Angeles 21, Calif.

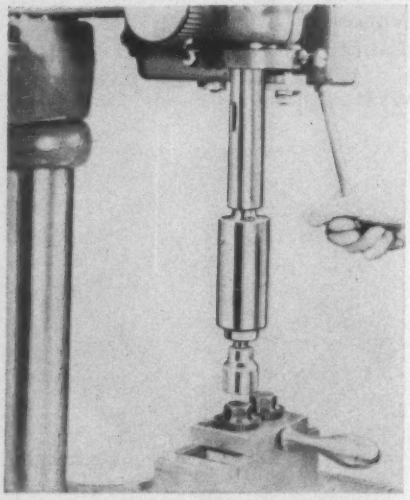
Circle No. **47** *on Reply Card*



Motor, Tachometer-Generators

Compact, lightweight, permanent magnet type dc motors and tachometer-generators are suited to airborne and similar applications. Only 3-11/16-in. long and 1¾-in. diameter, units weigh less than 20 oz. Used as continuous duty motors from 1/30 to 1/100-hp, they operate on 6 to 27.5 v from 3000 to 9000 rpm. Used as tachometer-generators, they have 0.46 to 2.4 v dc output per 100 rpm up to 9000 rpm. **Instrument Motors,** P.O. Box 5, Acosta St., Stamford, Conn.

Circle No. **48** *on Reply Card*



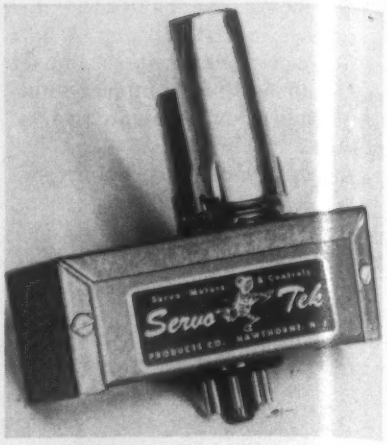
Machine Tool Torque Wrench

A small torque wrench, Acuritork, is adjustable for any predetermined torque from 5 to 45 ft-lb for use on machine tools with single or multiple spindle operations. It automatically drives bolts, studs, nuts, cap screws, spark plugs to any predetermined torque. Shaft must be depressed to engage tool before it starts to drive the piece. Tool can be used with any adapter, and arranged to fit any socket. In the automotive industry, the wrench is used in assembling connecting rods and caps, and in assembling rubber grommets in front wheel suspension of cars, both being multiple spindle operations. Necessity for torque inspection is eliminated. **B. E. Parish Co.,** 3340 Fenkell, Detroit 38, Mich.

Circle No. **49** *on Reply Card*

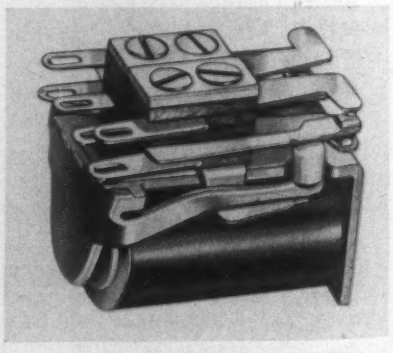
Reference Voltage Supply

Voltage is converted from ac to dc and maintained within ⅛ of 1 per cent by a new constant reference voltage supply. Designed primarily for variable speed motor drives and dc servo systems, unit can be used to replace standard



cells, wet or dry cells, and electronic regulating systems. Device operates at 50 to 400 cycles on 115 v to supply a reference potential adjustable from zero to approximately 87 v, and to maintain any desired voltage with stability. This reference voltage is maintained with any load not exceeding 1 ma in a temperature range of −50 to 40 C, and with line voltage changes between 90 and 135 v. In addition to high stability reference voltage, the two available models can supply for external use 275 v unregulated and not exceeding 5 ma, and 150 v plus or minus 2 v regulated not exceeding 5 ma. Both models supply a filament voltage of 6.3 v ac with center tap at a current not exceeding 0.6 amp. **Servo-Tek Products Co., Inc.,** 1086 Goffle Rd., Hawthorne, N. J.

Circle No. **50** *on Reply Card*



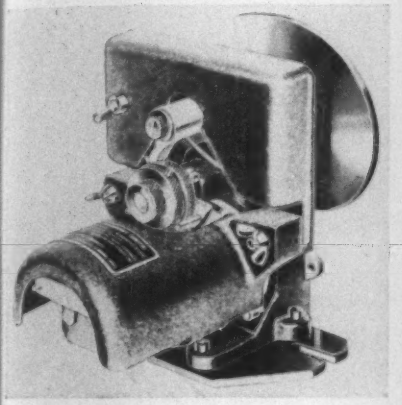
Miniature Telephone Type Relay

Suitable for communications apparatus, aircraft, radar, and all types of electronic equipment, a miniature telephone type dc relay is available for all standard volt-

ages up to 125 v dc, or 6500 ohm coil. Coil consumption averages 3 w, and vibration resistance is 10 g at 500 cycles per second, depending on contact sizes and combinations. Open type contact combinations can be supplied up to 6-pole, single-throw, and sealed type combinations up to 4-pole, double-throw.

Silver contacts rated 3 amp at 28 v dc, and 1 amp at 115 v ac, noninductive. Standard ambient temperature range is −55 to 85C, with special coils available for −65 to 125C. Life expectancy is at least 1 million cycles. **Comar Electric Co.,** 3349 Addison St., Chicago 18, Ill.

Circle No. **51** *on Reply Card*

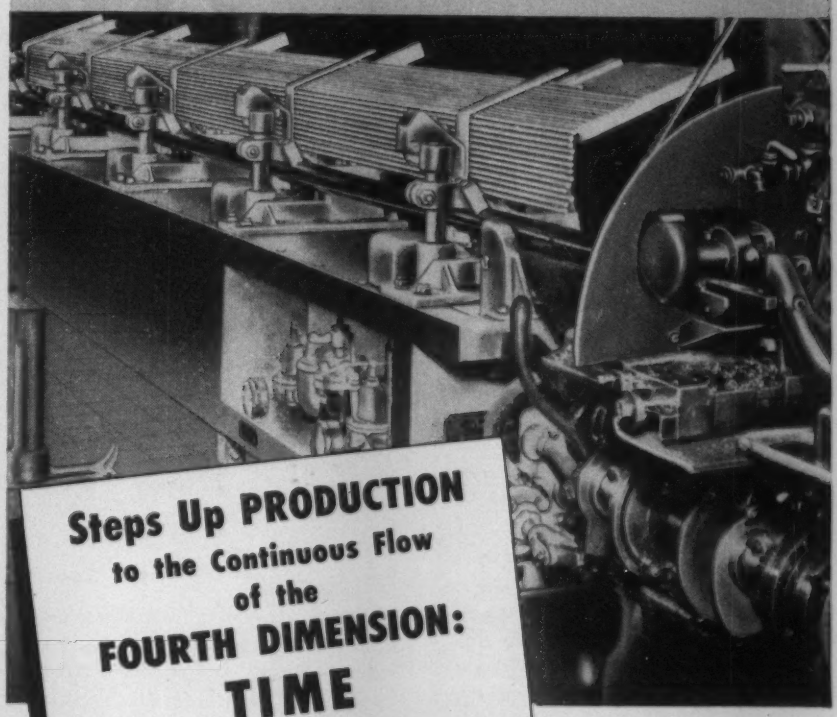


Range Selector

Originally developed as an automatic frequency control device for vibration test machines, a range selector can be adapted to use with V-belt speed changing units or any cam actuated mechanism requiring variable rotation. Selector consists of a fractional horsepower speed reduction motor which turns a camshaft. Two accessible disks on the shaft are turned manually. Each disk has a stop pin which actuates a limit switch to reverse the cam's rotation. Larger disk controls the high limit and small disk the low. Cam is available in a variety of shapes to suit particular application. Installed on a machine, selector can be set so that cam turns a half, quarter, or any other fractional revolution. Space requirement is 7 x 8¾ x 9½ in. **All American Tool & Mfg. Co.,** 8027 Lawndale, Skokie, Ill.

Circle No. **52** *on Reply Card*

Now... A Screw-Machine-Feed that BREAKS THE TIME BARRIER!



Steps Up PRODUCTION to the Continuous Flow of the FOURTH DIMENSION: TIME

EVERY TIME a screw machine cuts air . . . every time feed fingers are adjusted or replaced . . . every time remnant removal forces a shut-down — *that's time lost forever, never again to be made up in the production quota!*

In the modern Lipe Automatic Magazine-Loading Bar Feed, we present a continuous-feed mechanism that utilizes *every minute* of the working day for production . . . and still more production.

There's *No* cutting air. *No* feed fingers. *No* remnant problem. *No* minimum or maximum run. *No* limit on length of feed. *No* selective stock length requirement.

There IS a definite increase in production — up to 100% on some installations — *at least 30% on every one!*

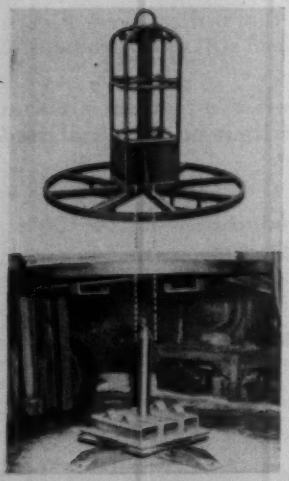
Send today for FREE BOOKLET giving full details on Lipe's AML Bar Feed — today's big advancement in screw machine stock feeding. We will also supply name of your nearest distributor.

Lipe-ROLLWAY CORPORATION
Manufacturers of Automotive Clutches and Machine Tools
Syracuse 1, N. Y.

Polyester Film Backed Tape

Two types of magnetic "Scotch" brand tape are now available on high-strength polyester backing as well as on conventional acetate backing. Plastic base "PE" backing is recommended for magnetic recording applications requiring resistance to temperature and humidity changes. Successful applications include use in dictation recorders, endless loop-tape machines, and high speed industrial and scientific recorders. Tape is only ¼-in. wide yet has tensile strength to withstand a 9 lb pull. It has much greater tear resistance and less elongation or shrinkage under temperature and humidity changes than acetate tape. Tapes are silicone "dry-lubricated", and are available in 600, 1200, 2400, and 4800 ft lengths. **Minnesota Mining & Mfg. Co.**, 900 Fauquier St., St. Paul 6, Minn.

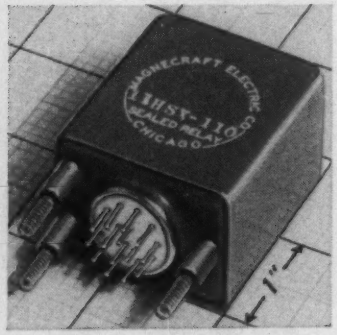
Circle No. **53** *on Reply Card*



Reel and Stand for Steel Coil

A cost-saving rotary device reduces production downtime by feeding steel coil from a reel directly. Reel is built to any capacity and is used in conjunction with a heavy duty stand which has ball bearing raceway to hold the reel. Adaptors on reel will handle coil of any diameter. Reel provides space-saving storage, is easily transported by fork truck or crane. Entire unit is of all-welded steel. **Palmer-Shile Co.**, 16040 Fullerton, Detroit 27, Mich.

Circle No. **54** *on Reply Card*



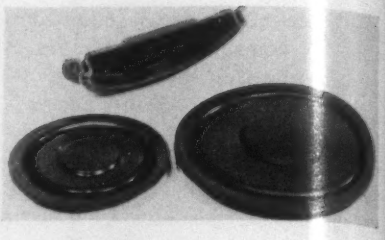
Sealed Relay for Small Space

Small dc relay is designed to meet application requirements where space is limited. Hermetically sealed in metal container, entire unit measures 1⅛ x 1-9/16 x 1-13/16-in. Solder terminals or 14-pin miniature plug are available. Weight of relay puts no strain on solder seals because relay and container interlock. Unit can be furnished to resist shock and vibration and to withstand temperature variations. Possible contact combinations range up to 4-pole, double throw, and added combinations are available in larger containers. Resistance range is 0.12 to 11,000 ohms, voltage can run to 115 dc and entire unit weighs approximately five oz. **Magnecraft Electric Co.**, 1450 W. Van Buren St., Chicago 7, Ill. Ill.

Circle No. **55** *on Reply Card*

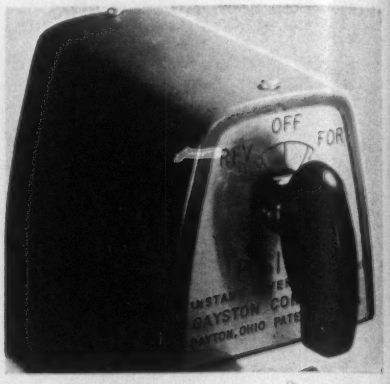
Stroking Diaphragm

A frictionless stroking diaphragm, known as the Sensater, is designed for weighing, tension measuring, pressure transmission, controlling, and positioning in high pressure hydraulic or pneumatic systems. Three-ply diaphragm is 7 inch diameter, displaces 23 cu



in. of fluid, and withstands 5400 psi. Unit is flexible and features low hysteresis. **Martin-Decker Corp.**, 3431 Cherry Ave., Long Beach, Calif.

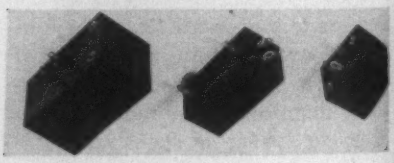
Circle No. **56** *on Reply Card*



Condenser Motor Reversal

"Positrol", a new drum reversing switch, instantly and positively reverses single-phase, condenser-start type electric motors up to 2 hp, and eliminates need for special wiring circuits. Momentary contact pole and special circuit are built into the switch, which is connected to the motor's centrifugal switch to reverse motor shaft instantly. Reversal is no harder on the motor winding than a normal motor start. Switch also can be used to reverse polyphase motors up to 2 hp and ¼-hp dc motors. **Gayston Corp.**, 1217-18 Ray St., Dayton, Ohio.

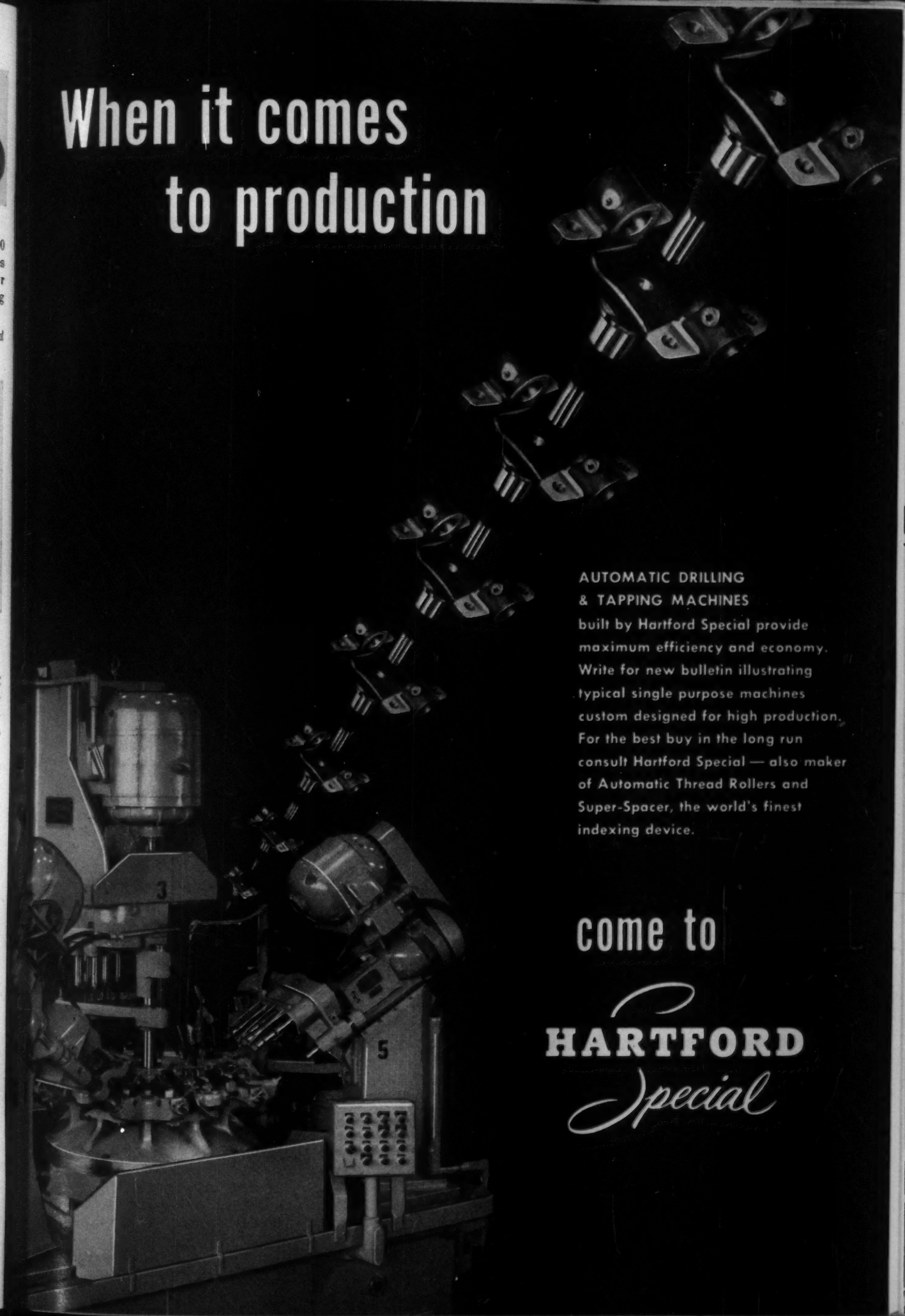
Circle No. **57** *on Reply Card*



Delay Lines

Three new series of military type delay lines are available, all covering the same general ranges of

When it comes to production



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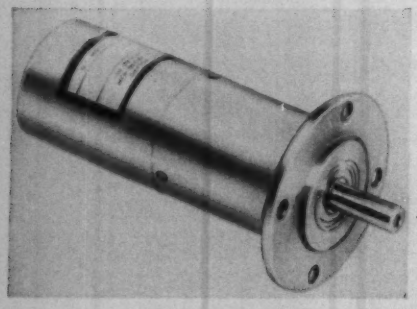
impedance and delay time but differing basically in number of sections in construction, consequently in ratio of delay time to rise time. Series V has largest ratio, Series U is simpler and more compact, and Series T is the smallest. All models are encapsulated in thermally stable resin which seals them hermetically and enables them to withstand shock and vibration. Lines have excellent thermal coefficients of delay and offer a wide range of characteristic impedances and delay times. They may be panel or chassis mounted, and have solder lugs for external connections.

Company's subminiature series of delay lines has extended its range of delay times by the addition of items for the 2.5 to 0.1 microsecond range, and a 3 microsecond line. Subminiature models are also encapsulated. **Jacobs Instrument Co.,** 4718 Bethesda Ave., Bethesda 14, Md.

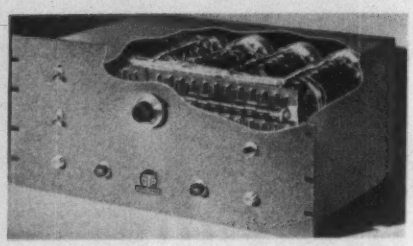
Circle No. **58** *on Reply Card*



Planetary Gear Reduced Motor

Subminiature, aircraft quality, planetary gear reduced motor is designed for maximum output torque in the smallest possible space. Motor is ⅞-in. diameter, weighs as little as 5 oz, and varies in length from 2½ to 3-11/64-in., depending on speed reduction ratio, 19 of which are available. Motor consists of an SS Moto-Mite (a premanent magnet dc motor) and a system of precision machined planetary gearing. It can be equipped with speed governors, standard or custom mounting flanges, and separate radio noise filters. Unit meets military environmental protection and temperature requirements. **Globe Industries, Inc.,** 1784 Stanley Ave., Dayton 4, Ohio.

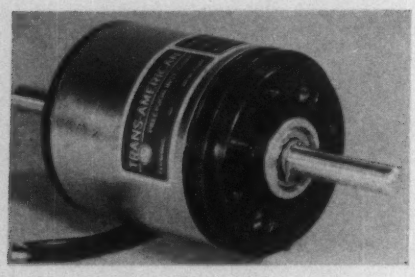
Circle No. **59** *on Reply Card*



Sweep Digitizer

Quantasweep is a low torque digitizer which converts either shaft positions or voltages into digits. Any information which can be measured by shaft rotation or voltage, such as speed, pressure, tension, weight, remote temperature, or humidity, can be converted. When the input is a shaft position, a low torque potentiometer on the shaft converts its positions into voltages. Output commutators can operate card or paper tape punches. Digitizer's least count is one part in 10,000, precision is 0.025 per cent of full scale reading. Torque for actuation may be as low as 0.007-in.-oz. **EE Div., Oerlikon Tool & Arms Corp. of America,** Asheville, N. C.

Circle No. **60** *on Reply Card*



Magnetic Clutch

An electromechanical magnetic clutch is suitable for use in precision computers, guided missile instrumentation and controls, automation control equipment, and servomechanisms. Input and output shafts are magnetically coupled when coil is energized, and couplings will not induce angular displacement error into the system upon engagement. Operating at 24 v dc, the clutch has a maximum output torque of 110 in.-oz and a minimum of 50 in.-oz. Power consumption is 3 w and engagement takes 3 milliseconds. Unit is 1¾-in. diameter and approximately 2 in. long. Manufacturer modifies shafts, provides any length terminal or cable, and supplies precision gears to customer's specifications. **Trans-American Precision Instrument Corp.,** 34-17 Lawrence St., Flushing 54, N. Y.

Circle No. **61** *on Reply Card*

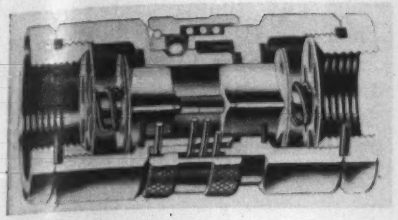
Meter Controller

Most electrical indicating and recording instruments can be converted into automatic controllers or monitors when this new meter controller is applied to the installation. Approach to or deviation from preset limits of factors such as radiation, pH, pressure, flow, strain, vibration, or voltage can actuate alarms or counters, or complete closed-loop control systems. The low impedance, positive locking, contact meter movement can be placed in series with standard movements of most indicating instruments with negligible effect on accuracy. Double pole, double throw output relay contacts, terminals, a panel signal lamp, and all necessary circuits and adjustments are provided. **Daytronic Corp.,** 216 S. Main St., Dayton 2, Ohio.

Circle No. **62** *on Reply Card*

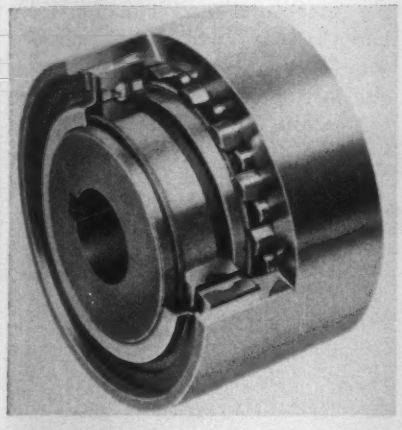
Heavy Duty Coupling

Quick connect-disconnect coupling is designed for high pressure and heavy surge applications, is available in ⅛ to 10-in. ID sizes. A metal to metal valve stop in the closed position permits positive control of compression of valve's washer sealing member regardless of surge or pressure build-up in the line. A barrel spring with a perforated "spider" and full circle



valve stop and guide holds valves steady in open position, allowing no valve float, and permits high pressures and surges in both directions through the coupling or pulsating surges in both directions. Seal is based on a "pass-through" principle so that the higher the pressure builds in the line the tighter the seal becomes. Couplings are usually made of a high tensile strength alloy steel, but are available in stainless steels and nonferrous materials. **Snap-Tite, Inc.,** 201 Kelly St., Union City, Pa.

Circle No. **63** *on Reply Card*



Machine Drive Cam Clutch

Low cost, plain bearing cam clutches for indexing, overrunning, and backstop applications, are designed basically for operation in the lower speed and torque ranges. They can be used in conjunction with standard shafting on press feeds and two-speed drives, and as backstops and overrunning clutches in machine drives. Each unit consists of long bronze bearing, hardened and ground steel inner and outer races, a full complement cam and energizing spring assembly, a snap ring, and a grease fitting for lubrication. Constant-pitch spacing design prevents cam crowding and single cam locking conditions. The

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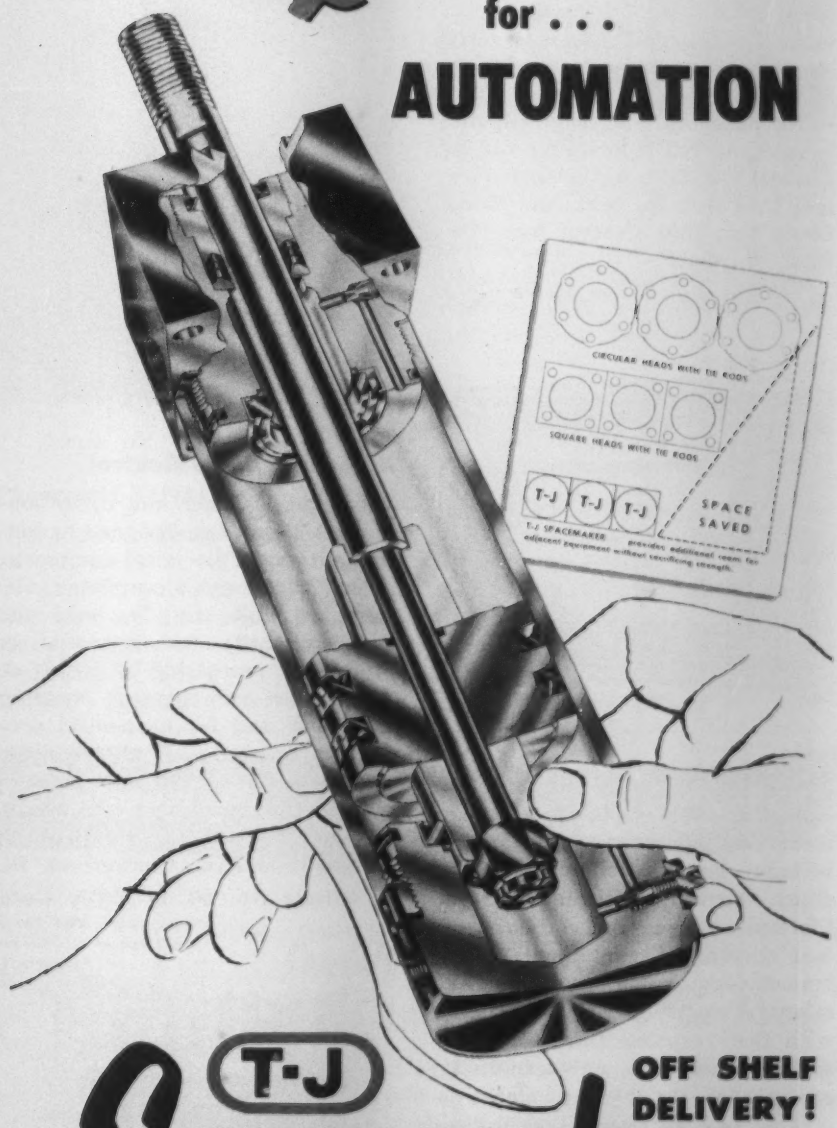
AUTOMATION



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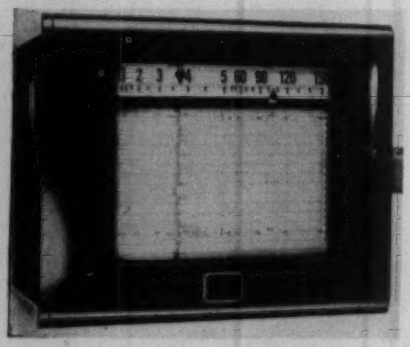
★ New Compact Design . . . Saves up to 40% Space
★ Proven Performance . . . with Extra High Safety Factor
★ Super Cushion Flexible Seals for Air . . . New Self-Aligning Adjustable Oil Cushion
★ Hard Chrome Plated Bodies and Piston Rods

Compare feature by feature—you'll see why T-J Spacemaker Cylinders are today's top choice for streamlined power movement in automation! The only cylinder with all the extras as standard. Write for bulletin SM-454-2.
The Tomkins-Johnson Co., Jackson, Mich.

T-J TOMKINS-JOHNSON

shape of the cam prevents its rolling over under overload or peak torsional loads, injuring races, or damaging energizing springs. Clutch is available in seven sizes ranging from 2 in. OD and 2 in. long to 5¼-in. OD and 4⅜-in. long. The smallest model is rated at 8.2 ft-lb torque for indexing, 16 ft-lb for general duty, and 23 ft-lb for backstop. The largest clutch is rated at 545 ft-lb torque for indexing, 1075 ft-lb for general duty, and 1584 ft-lb for backstop. **Morse Chain Co.**, 7601 Central Ave., Detroit 10, Mich.

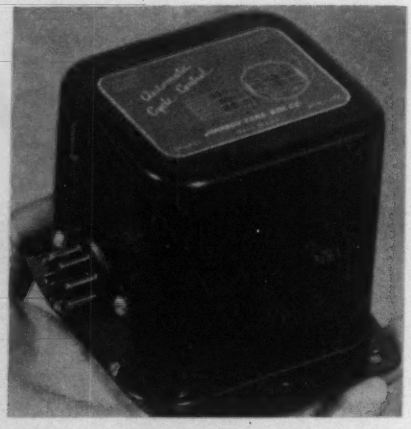
Circle No. **64** *on Reply Card*



Voltmeter-Ammeter Recorder

A wide strip electronic recorder measures and records current and voltage simultaneously on one chart. Measuring elements are a thermal voltage converter, a thermal current converter, and ac-dc transducers. Instrument is a Dynamaster electronic potentiometer with fast response time, accuracy within 1 per cent, and sensitivity of 1/20 of 1 per cent. Chart is divided into two zones, one to record amperes and one to record volts. Calibration of both is according to the law of squares, giving expanded graduations in the normally used section of the range. Chart speeds are available from ¾-in. per hour to 4 ips through easily changed gears. Pen speed can be as fast as 1½ seconds for full scale travel. High torque output permits addition of auxiliary functions, such as high-alarm contacts or retransmitting slidewires, without loss of accuracy or sensitivity. Combined with thermal converter the Dynamaster provides a basic voltage telemetering system which can transmit over a considerable distance without additional equipment. **Bristol Co.**, Waterbury 20, Conn.

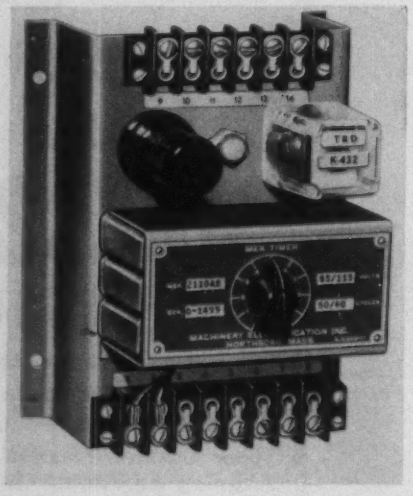
Circle No. **65** *on Reply Card*



Automatic Cycle Control

Automatic timer and cycle control sensing device designed to control automatic electrical equipment operating through a complete cycle. Compact unit can be used for timed quantity measurements in production processing of liquids or solids, for coin-operated vending machines, and for sequential production operation. Cycle of operation may be set for any requirements—two seconds or two weeks. **Johnson Fare Box Co.**, 4619 N. Ravenswood Ave., Chicago 40, Ill.

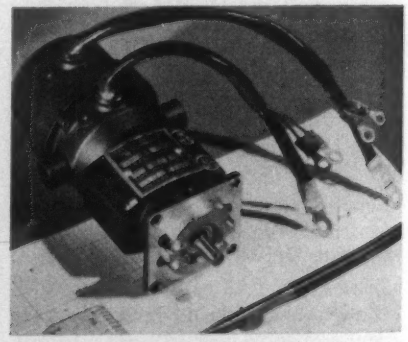
Circle No. **66** *on Reply Card*



Time Delay Relay

Adjustable electronic time delay relay allows a choice of two sequences of operation. Load contacts can be de-energized during reset and timing and energized when timed out, or can be energized during reset, de-energized during timing, and energized when timed out. Sequences are obtained by interchanging terminal strip connections. Two timing ranges are available: 1.5 to 120 seconds, and 0.75 to 60 seconds. Double-pole, double-throw load contacts, rated at 5 amp, 115 v ac, control external circuits. Repetitive accuracy is said to be better than ±2 per cent when line voltage is constant. Slight increase or decrease in preset time is caused by variation in line voltage. For instance, a 10 per cent increase in the line decreases the timed interval by approximately 1 per cent. Reset time of 3 per cent of set time must be allowed between operations. A factory-set calibration control compensates for variations due to tolerances in components. Recommended for interval timing or time limiting, unit is applicable to heat treating machines, injection molding machines, and machine tools. Units may be combined for complex sequences, are available in open or enclosed models. **Machinery Electrification, Inc.**, Northboro, Mass.

Circle No. **67** *on Reply Card*

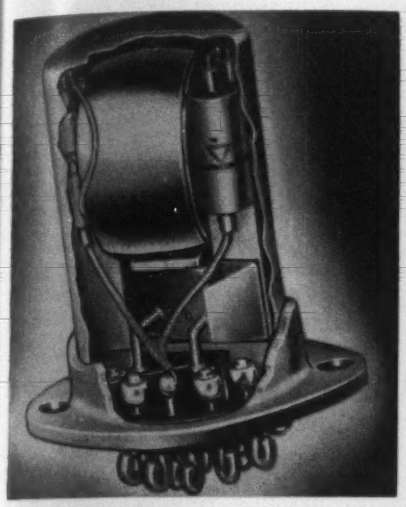


Permanent Magnet Motor

Flange-ring mounting for quick attachment by clamps or retaining rings is featured in a new permanent magnet motor. Unit has motor connections to snap-in terminals, as well as an internal capacitor to minimize radio frequency interference. Rating is 27 v dc, and output is 20 w at 6000 rpm on a continuous duty cycle with a large overload capacity. Several models are available including output shafts with splines and tangs. Mo-

tor can be furnished with alternative electrical connections. **Dalmotor Co.**, 1304 Clay St., Santa Clara, Calif.

Circle No. **68** *on Reply Card*



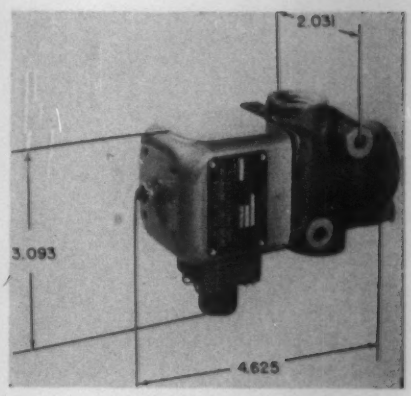
Relay and Built-in Rectifier

Four miniature germanium diodes are incorporated in this ac-dc relay to rectify ac excitation signals and provide chatterless dc switching action. Diodes are hermetically sealed in the standard relay can and allow heat conduction through the can wall. Relay networks can be operated directly off the ac power line without using dc rectifiers. Relays also operate on dc excitation of either polarity. A balance rotating armature in the relay withstands shock accelerations exceeding 100 g and vibration accelerations exceeding 20 g over the frequency range of 2 to 2000 cycles per second. Magnetic circuit drives 1, 2, 4, and 6-pole ganged contact arms against silver ball contacts. Contact currents of 4 amp, with resistive load, can be controlled with contact life in excess of 100,000 operations, and higher currents can be handled with shorter life. **Hi-G Inc.**, Bradley Field, Windsor Locks, Conn.

Circle No. **69** *on Reply Card*

Pneumatic Valves

A line of solenoid operated shutoff and selector valves is offered for aircraft, guided missile, and industrial applications. Pressure range is from 0 to 3000 psi, and temperature range is from −65 to 265 F. Electrical current drawn



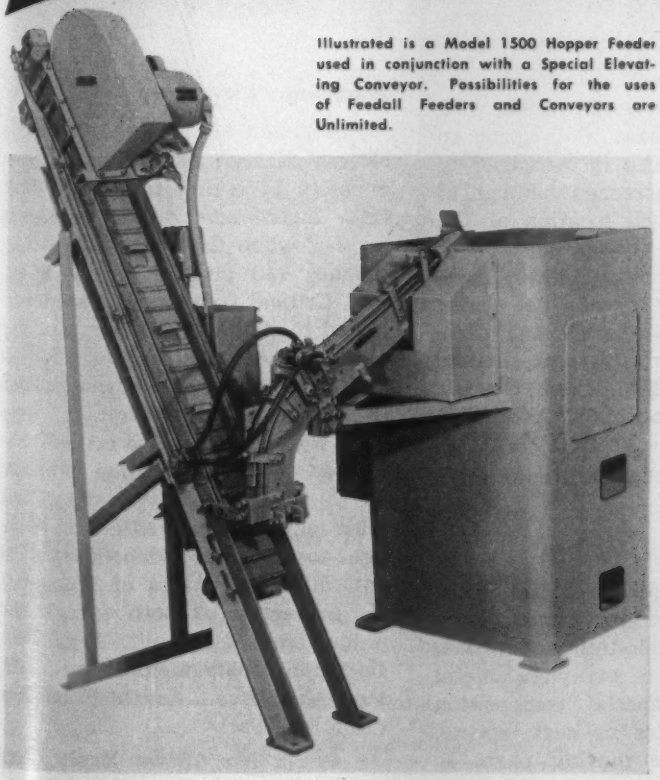
is less than 1 amp at 24 v dc, continuous duty. **Mar Vista Engineering Co.**, 5420 W. 104th St., Los Angeles 45, Calif.

Circle No. **70** *on Reply Card*

Low Friction Accelerometer

Potentiometer type ratio accelerometer is proportional within 2 per cent with 300 ohms overall resistance. Power dissipation is 20 w, and operating temperature range is −67 to 160 F. Potentiometer element mounts coaxially with dashpot assembly to provide low friction on the sensitive axis. Her-

Automatic Feeders Speed Production...Reduce Costs



Illustrated is a Model 1500 Hopper Feeder used in conjunction with a Special Elevating Conveyor. Possibilities for the uses of Feedall Feeders and Conveyors are Unlimited.

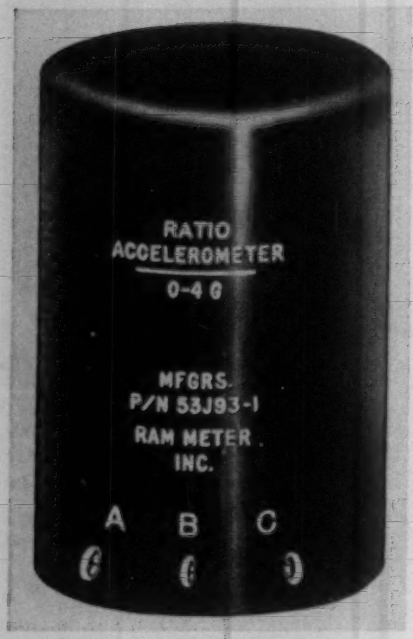
Consult FEEDALL *for Correct Models to Meet Your Needs*

This particular FEEDALL Automatic Hopper Feeder operates with an oscillating blade or center board which picks up the parts and delivers them to the chute. The elevating conveyor positions the parts for feeding into the next automatic machine.

FEEDALL Automatic Feeders are made in many Models with Hopper Feed, Rotary Feed, Vibratory Feed or Blade Feed as may be best suited to the job at hand. All machines are factory tested and are delivered completely assembled, ready to set in position and operate.

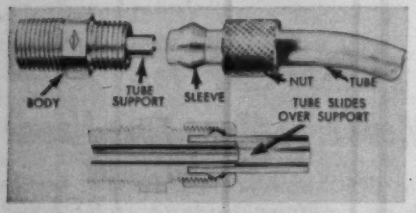
Send samples or prints with your production requirements, and we will send you welcome information about FEEDALL Feeders.

FEEDALL
MACHINE AND ENGINEERING CO.
WILLOUGHBY, OHIO, U.S.A.



metic sealing permits constant self-dampening. Accelerometer can be provided as a voltage divider resistor with single or multiple turn action, or with linear action in any resistance range desired. Unit is 2½-in. long, 1⅝-in. in diameter, and weighs only 5 oz. **Ram Metor, Inc.**, 1100 Hilton Rd., Ferndale, Detroit 20, Mich.

Circle No. **71** *on Reply Card*



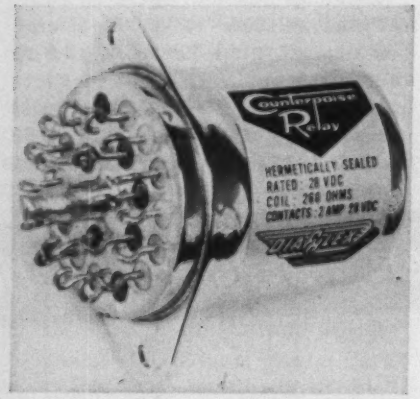
Hand Assembled Tube Fittings

E-Z tube fittings for use with Poly-Cor instrument tubing harness and "P" tubing require no tools for installation, are tightened by hand yet will withstand severe vibration and major tube movement without loosening. This fitting is available in 16 different models, each in several sizes. Elbows and tees are of brass forging to eliminate leakage through porosity. Connectors, unions, nuts are of bar stock, and sleeves are polyethylene. Also featured are quick disconnect shut-off valve connectors and unions to go from plastic to metal tubing. **Dekoron Product Div., Samuel Moore & Co.**, Mantua, Ohio.

Circle No. **72** *on Reply Card*

Precision Counterpoise Relay

Counterpoise relay is designed on the fulcrum-lever principle whereby two balanced weights act in the same direction as equal and opposite distances from the fulcrum so that no motion can occur. When the relay coil is energized and de-energized a force couple is produced giving the lever a smooth, rocking motion which is transmitted to the relay contacts. Therefore, mechanism is responsive to electrical energy only. No solder, brazing, riveting, clinching, screws, threaded parts, fasteners, washers, or safety wiring are used in relay's construction. The majority

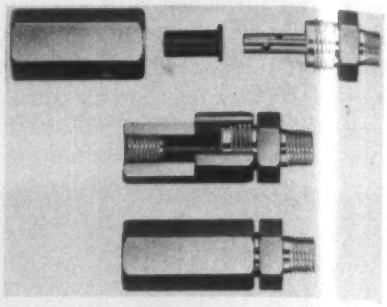


of the assembly work is done with magnifying glasses. Coil space to total volume ratio is increased to 80 per cent. Increased number of turns and midcoil location of the actuator anvil provide high magnetic force, increased gram pressure and spring travel. The sealed assembly is leak-tested and pressurized with dry nitrogen helium gas. **Diaphlex Div., Cook Electric Co.**, 2700 N. Southport Ave., Chicago 14, Ill.

Circle No. **73** *on Reply Card*

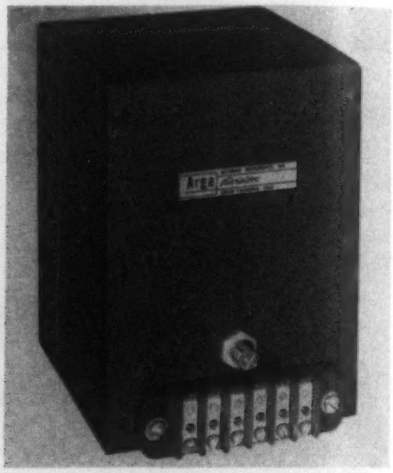
Check Valve

A check valve provides maximum flow with low opening pressures and bubble-tight operation. Consisting of a two-piece metal body and a special composition sleeve, valve has no seat, spring, or other metal moving parts to



wear or slip alignment. Sleeve is easily replaced if damaged. Valve may be mounted in any position, is immune to vibration, and is supplied in a wide range of sizes and materials. **Betts Machine Co.**, 1800 Pennsylvania Ave. W., Warren, Pa.

Circle No. **74** *on Reply Card*



Frequency Limit Trip

Equipment is protected from the effects of high or low power frequencies by a new frequency limit trip. Instrument opens or closes a relay when the signal frequency reaches 440 plus or minus 2 cycles. Critical frequency is predetermined to within ± ½ per cent for any value of frequency between 50 and 5000 cycles, and trip operation is independent of voltage over very wide limits at the critical frequency level. Operation is from 30 to 150 v signal voltage. Two trips may be combined in one package to operate independently at two different values of frequency for protection at both a high and a low frequency limit. **Arga Div., Beckman Instruments, Inc.**, 220 Pasadena Ave., South Pasadena, Calif.

Circle No. **75** *on Reply Card*

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AUTOMOTIVE, INDUSTRIAL EQUIPMENT, DOMESTIC APPLIANCE, AGRICULTURAL INDUSTRIES AND OTHERS; will boost your output at material savings.

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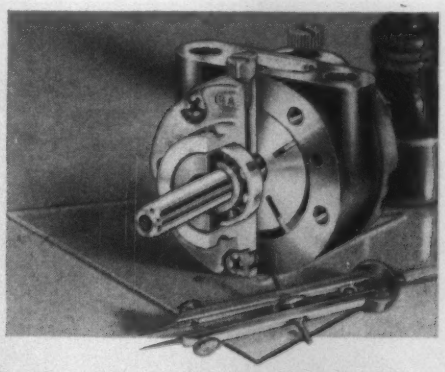

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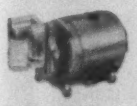
SIMPLE PRINCIPLE

Air Compressors to 30 p.s.i. to 24 c.f.m.



Vacuum Pumps to 28 in. to 24 c.f.m.

Always striving for simplicity in your products? So are we. Simplicity lowers costs — increases dependability. And it's a *big* reason why engineers and users favor Gast components.

A rotor and four sliding vanes are the only moving parts. Centrifugal force holds self-seating vanes tightly against the interior of housing, maintaining a continuous seal, and taking up any wear automatically. Air delivery is positive, pulseless, quiet . . . without bulky air tank.

Get the advantages of Gast simplicity for *your* products! *Write for new "Application Ideas" Booklet — and request data on specific models.* Gast Manufacturing Corp., P.O. Box 117-E Benton Harbor, Michigan.

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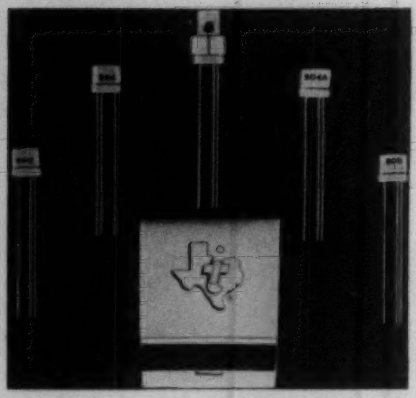
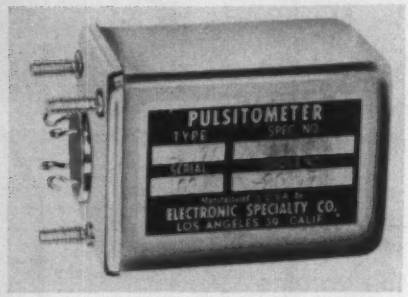


Silicon Transistors

Two models have been added to company's line of silicon transistors, making a total of five for various computer, aircraft, and guided missile applications. Grown junction silicon transistors operate with little change at 150C. Average alpha (current amplification factor) cutoff frequency is 3 megacycles for three of the models, with alpha guaranteed to be from 0.95 to 0.975 with #904; 0.975 or better with #905. Alpha cutoff frequency is 8 megacycles or better and alpha is 0.95 or better with #904A. The X-15 large signal model gives a power gain of 14 db with collector dissipation of 1 w in Class B operation. **Texas Instruments, Inc.**, 6000 Lemmon Ave., Dallas 9, Tex.

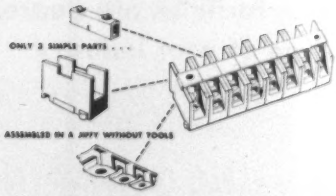
Circle No. **76** *on Reply Card*



Airborne Time Delay Relay

Accurate, reliable, vibration resistant time delay relays are particularly well suited to airborne applications. Incorporating a resistor capacitor circuit, these relays feature more reliability, shorter reset time, and more resistance to vibration than thermal type timers. Operating range is 18 to 30 v dc and resistance load contact rating is 5 amps. Quickly recycled, units have minimum life of 500,000 cycles. Factory set timing period can be from 15 to 500 milliseconds. Relays are available one to four pole, single or double throw, with various bases which include miniature tube plug-in and solder terminals. Housings are hermetically sealed and filled with inert gas. Size is 1⅝ x 1-7/16 x 2¼-in., and weight is 6½-oz. **Contract Div., Electronic Specialty Co.**, 3456 Glendale Blvd., Los Angeles 39, Calif.

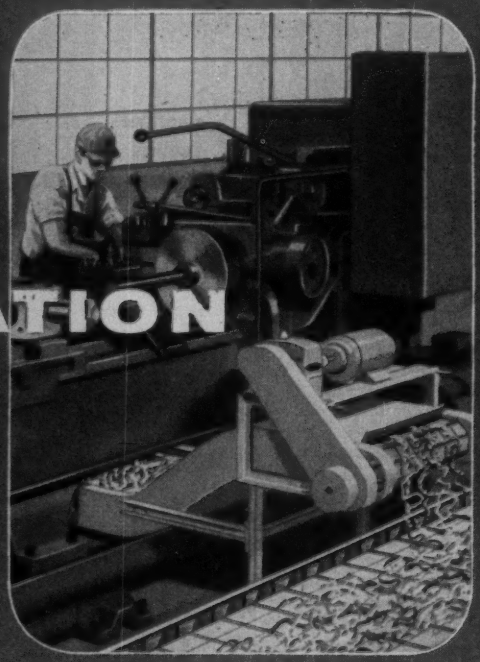
Circle No. **77** *on Reply Card*

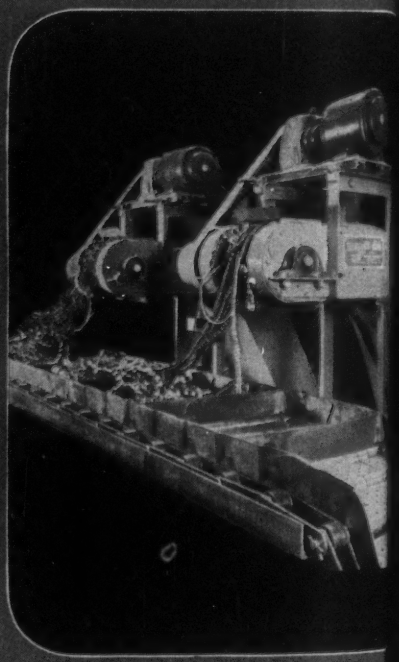


Hand Assembled Terminal Blocks

Lok - A - Blok permits building of terminal blocks in various

May-Fran
. . . first
for
AUTOMATION
in
scrap
handling
systems





The CHIP-TOTE conveyor permits complete utilization of machine tools by eliminating shut-down for manual scrap removal.

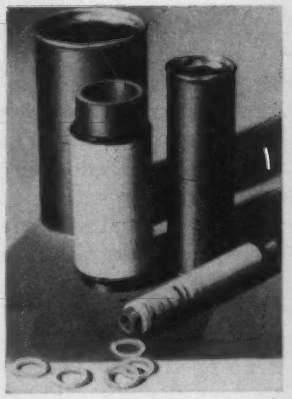
It handles a continuous flow of hot, wet or dry chips, turnings and borings from any multiple spindle automatic machine.

lengths and combinations up to 25 poles, without waste, according to user's requirements. Three simple components are easily assembled without tools as follows: (1) solderless connectors fit into (2) red Lok-A-Blok housings which are assembled and held together by (3) a yellow Lok-Strip which also acts as identification strip. Mat finish on top of strip can be marked in pencil or ink with identifying numbers. Hand tool is available to ream necessary holes for mounting. Unit has a clearance "over surface" of ¾-in., and "thru air" of ½-in. on live metal parts. Wiring is installed rapidly by use of solderless connectors instead of washer head screws. Lugs or connectors are of pure electrolytic copper. **Ilsco Copper Tube & Products, Inc.**, Mariemount Ave., Cincinnati 27, Ohio.

Circle No. **78** *on Reply Card*

Spiral Backups for O-Rings

Spiral series of chamfered backup rings is packaged on mandrels and shipped in tubular containers to ease handling and prevent damage. Teflon backups prevent O-



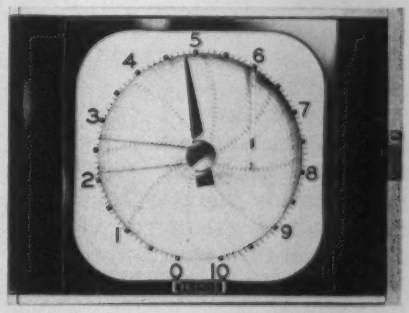
ring extrusion and reduce packing friction, protect ring from nibbling and prevent spiral failure. Ring performance is improved consequently at high temperatures and in fluids which might have adverse effect upon ring material. Backup rings can seal without O-rings provided the packing completely fills the groove in one continuous spiral of several layers. Packaging meets military specifications. **W. S. Shamban & Co.**, 11617 W. Jefferson Blvd., Culver City, Calif.

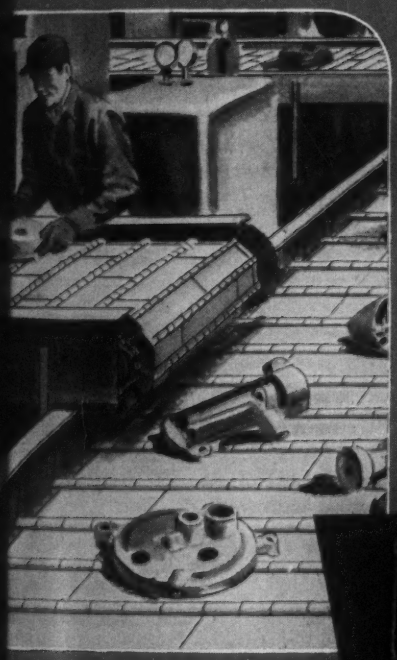
Circle No. **79** *on Reply Card*

Standardizing Potentiometer

Electronic Dynamaster potentiometer is available in round and strip chart models with intermittent automatic or pushbutton manual standardization. Constant voltage source and regulator continuously standardize the instrument and eliminate dry cells, yet retain the standard cell for accuracy. Instrument regulates the output of a dry disk rectifier to reasonable limits and floats a standard cell across the load to further reduce deviations of load value from the required value. Intermittent interruption of control is eliminated. **Bristol Co.**, Waterbury 20, Conn.

Circle No. **80** *on Reply Card*





Hinged-steel belting handles scrap as well as hot heavy and abrasive castings. Belt is economical . . . maintenance-free.

Now is the time to put AUTOMATION to work . . . Now is the time to cut production costs . . . May-Fran engineers design and build complete scrap handling systems for the automatic removal of machine turnings or chips. May-Fran conveyors will transmit scrap to ultimate point of disposal.

Press Scrap systems can be made completely automatic. Hinged-steel belt will take scrap from presses, handle it through blanking, shearing, forming and baling processes, and deliver it to rail cars.

May-Fran is prepared to engineer, fabricate and install complete conveyor systems to your specifications.

Write today for complete information on how an automatic scrap removal system will cut your production costs.

Bulletin MF-530 describes the new Hinged-Steel conveyor belt.

Bulletin MF-640 describes the Chip-Tote conveyor which removes scrap from operating machines.

DESIGNERS AND ENGINEERS OF COMPLETE SCRAP HANDLING SYSTEMS

MAY-FRAN ENGINEERING, INC.

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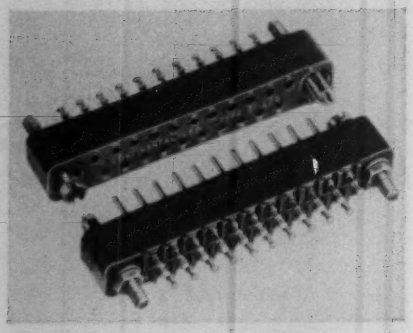
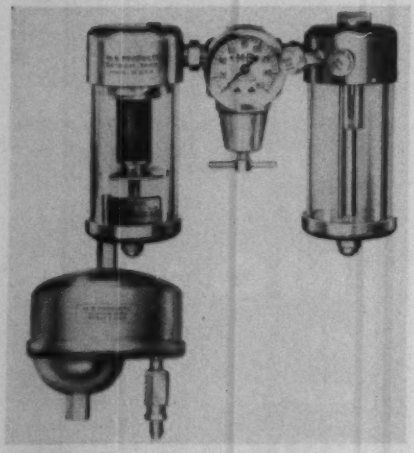


Multi-Contact Connectors

Series of connectors is now available with turret terminals and choice of 7, 8, 9, 11, 14, 18, 21, 26, 34, 41, 50, 75, or 104 contacts. Aluminum hoods and polarizing screwlocks can be used with the connectors. Two No. 20 AWG wires can be soldered to one contact. Units are furnished in mineral filled Melamine, Plaskon reinforced (glass) Alkyd 440A, and Diallyl Phthalate with mineral or orlon filler insulation. Orlon has quick recovery characteristics after humidity tests, shows no absorption of moisture after 24-hour exposure. **DeJur-Amsco Corp.**, 45-01 Northern Blvd., Long Island City 1, N. Y.

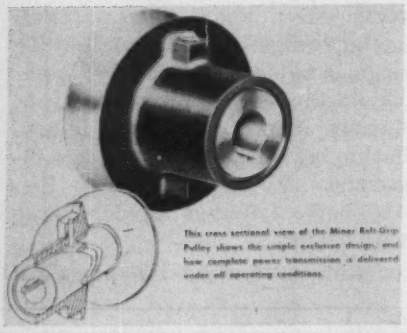
Circle No. **81** *on Reply Card*



Automatic Water Ejector

An automatic water ejector assures dry air in pneumatic systems, provides preventive maintenance for the system, and eliminates costly downtime. It can be used successfully for all pneumatic applications including air valves, air motors, air cylinders, air tools, air vises, air presses, air hoists, air chucks, and spraying equipment. Water is automatically ejected upon accumulation of 3 to 4 oz, and ejection takes less than five seconds. Capacity is as high as 20 gph. Standpipe extends far into the filter. Constant water leg increases water removal efficiency of the filter without danger of carryover. Heavy solids become trapped in the filter bowl where they are easily removed, and, therefore, cannot enter the trap to cause clogging. Sump has ¼-in. NPT cleanout connection which is plugged when trap is in service. **M-B Products**, 46 Victor Ave., Detroit 3, Mich.

Circle No. **82** *on Reply Card*



This cross sectional view of the Miner Belt-Grip Pulley shows the simple exclusive design, and how complete power transmission is delivered under all operating conditions.

Belt Grip Pulley

Variable diameter, springless type V-belt pulley allows increased hp rating for belts, eliminates belt adjustment, and increases belt life. Each pulley replaces a series of sizes of ordinary sheaves by giving stepless speed variations, changing pitch diameter without loss of driving torque. All belt slippage and necessity for multiple groove sheaves for high starting or running torque is eliminated. Automatic tensioning permits fixed center drives. Pulley may be used as driver or driven member. If installed on equipment with one direction drive, the pulley protects against wrong way operation by not transmitting power opposite the installation. Among features claimed by manufacturer are increased hp rating, reduced bearing wear, self lubrication, and simple installation. **Miner Pulley & Transmission Co.**, 1201 E. 58 Ave., Denver 16, Colo.

Circle No. **83** *on Reply Card*

Tubeless Power Supply Unit

New 28 v 300 amp magnetic amplifier unit designed for application in aircraft and electronics industries. **Perkin Engineering Corp.**, 345 Kansas St., El Segundo, Calif.

Circle No. **84** *on Reply Card*

Silicon Junction Diodes

Devices have high forward conductance and high back resistance; can be used for numerous circuit applications. **Semiconductor Div., Hughes Aircraft Co.**, Florence Ave. at Teale St., Culver City, Calif.

Circle No. **85** *on Reply Card*

Thermocouple Transfer Switches

Units designed for laboratory and production testing feature low and uniform contact resistance. **Daven Co.**, Dept. RC, 191 Central Ave., Newark 4, N. J.

Circle No. **86** *on Reply Card*

Ceramic Cased Paper Capacitor

High humidity and temperature resistant units are designed for use under conditions too severe for conventional cardboard tubulars. **Aerovox Corp.**, New Bedford, Mass.

Circle No. **87** *on Reply Card*

Recording Pen

Stainless steel capillary pen has automatic inking supply. Unit is designed to facilitate record interpretation and analysis. **Bailey Meter Co.**, 1050 Ivanhoe Rd., Cleveland 10, O.

Circle No. **88** *on Reply Card*

Thermostatic Pilot Controller

Unit provides accurate temperature control of liquids or air when used with valves, dampers and control systems. **Fulton Sylphon Div., Robertshaw-Fulton Controls Co.**, Box 400, Knoxville 1, Tenn.

Circle No. **89** *on Reply Card*

Hermetically Sealed Relays

Differential relays which reset automatically are designed for overload, over-voltage, under-voltage or under-current protection. **Amperite Co.**, 561 Broadway, New York 12, N. Y.

Circle No. **90** *on Reply Card*

DC Power Supply

New ac to dc regulated selenium rectifier is designed for electronic and electrical applications requiring dc source. **Inet, Div. of Leach Corp.**, 4441 Santa Fe Ave., Los Angeles 54, Calif.

Circle No. **91** *on Reply Card*

Pressure-Run Potentiometers

Series of vibration-proof pressure-actuated potentiometers are designed for use in supersonic aircraft and missile application. **Trans-Sonics, Inc.**, Bedford Airport, Bedford, Mass.

Circle No. **92** *on Reply Card*

Pressure Transducer

Instrument is designed for high output to speed-altitude-time computers, telemeter systems, electric recorders, servo systems, meter display or alarms. **Technology Instrument Corp.**, Acton, Mass.

Circle No. **93** *on Reply Card*

Slides, Feeds and Tables

Machine tool attachments accommodate weights from 5 lb to 2500 lb; are available with single traverse and/or compound traverse. **Standard Electrical Tool Co.**, 2550 River Rd., Cincinnati 4, O.

Circle No. **94** *on Reply Card*

Temperature Measuring System

Unit is designed for industrial, airborne and laboratory use and provides high signal voltages required to operate telemetering systems, recording meters and oscillographs. **Arnoux Corp.**, 1357 S. Hawthorne Blvd., Hawthorne, Calif.

Circle No. **95** *on Reply Card*

Oil-Air Ratio Regulator

Proportioning unit maintains constant ratio of oil and air flowing through pressure burners at all firing rates. **Hauck Mfg. Co.**, 124-126 Tenth St., Brooklyn 15, N. Y.

Circle No. **96** *on Reply Card*

Axial Flow Blower

Compact blower designed for cooling airborne electronic equipment moves large volume of cooling air, has minimum external projection. **Components Div., Servomechanisms, Inc.**, 625 Main St., Westbury, N. Y.

Circle No. **97** *on Reply Card*

HYDRAULICS

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Selecting the right hydraulic component for each requirement takes years of experience — years of hydraulic system design and application. Picking the right supplier for all your needs is another problem sometimes solved by using more than one source. The common denominator for all your hydraulic problems can be the product line and experience background of H-P-M. A complete line of pumps, power units, valves, cylinders and accessories plus 77 years of hydraulic experience is the answer in most cases. When you're planning hydraulically, call on H-P-M. Write today for Bulletin 1101 — the handy condensed catalog of the complete H-P-M line.

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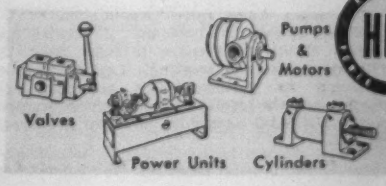

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HYDRAULIC POWER DIVISION

new catalogs..... latest literature

Let us get them for you

Here is the latest in automation "how-to"—yours for the asking.

Commutator Motors

Electric Indicator Co., Inc.—Twenty-two page brochure is reference on physical and electrical characteristics for "Elinco" line of commutator motors and governor units. Included are sections on field shunt and universal wound motors as well as permanent magnet and separately excited types. In addition, performance curves, dimensional drawings and specifications are given for each type listed.

Circle No. 91 on Reply Card

Engineering Research

Commonwealth Engineering Co. of Ohio—Thirty-four page bulletin discusses company's 15 years of engineering research and the products which have resulted. Photographs of wood finishing, fibre and bacteriological laboratories for chemistry and chemical process engineering are included. Mechanical and electrical engineering facilities and products are also given. Additional sections are devoted to pilot plant operation and data on protective coatings such as enamels, corrosion resistant metal finishes, etc.

Circle No. 92 on Reply Card

Universal Joints

Kuprian Mfg. Co.—Data sheet gives specifications for precision universal joints for remote controls, servomechanisms, motion transmission and instrumentation. Brief description of related double universal joints, pinless flexible joints and diaphragm type joints included.

Circle No. 93 on Reply Card

Transformer Catalog

Triad Transformer Corp.—Sixty new transformers are included in a list of over 500 found in current 28-page catalog. In addition, company's expanded lines of television components, hermetically sealed power components, instrument power supplies, filaments, chokes, power and audio transformer lines, and geophysical transformers are listed with prices.

Circle No. 94 on Reply Card

Dry Bulk Material Handling

J. P. Corrigan Co., Inc.—A bulletin on mechanical handling and storage of dry bulk materials follows material from unloading point to storage, and from storage to processing.

Circle No. 95 on Reply Card

Composite Instrumentation Catalog

Minneapolis-Honeywell Regulator Co.—Revised catalog features complete line of instruments and products from company's industrial division. Descriptions cover pyrometers, all types of potentiometers, thermometers, pressure gages, flow and liquid level meters, servo and safeguard systems, temperature detectors, pneumatic remote transmission systems, panelboards, valves, diaphragm motors, switches, starters, relays, ElectroniK systems and dampers.

Circle No. 96 on Reply Card

Automatic Surface Broaching

Colonial Broach Co.—Line of surface broaching machines is also efficient on internal push or pull broaching and general press operations, and is available with special circuits for automatic cycling and loading, as described in a 4-page bulletin. Automatic and semiautomatic fixtures, hydraulic clamping, and multiple broach setups are illustrated. Dimensions and specifications included.

Circle No. 97 on Reply Card

Natural Gas Monitoring

Arnold O. Beckman, Inc.—New bulletin describes danger and costly effects of air in gas lines in plants and compressor stations, and describes pipeline monitoring system and equipment to counteract the danger. Monitor continuously measures amount of air in the system, thus avoiding danger of explosion or loss due to pipeline deterioration, and maintaining heating value of the gas.

Circle No. 98 on Reply Card

Motor Control Centers

Continental Electric Equipment Co.—"Concentrol" standardized modular structures, which concentrate a large number of motor controls in one complete unit, are discussed in eight-page brochure. Structures are illustrated in three NEMA types: with unit starters, with motor and control terminal blocks at unit starters, and with unit terminal blocks plus master terminal blocks. Layout and short circuit application data, dimensions, ratings and specifications are included.

Circle No. 99 on Reply Card

Autronic Thermocouple Converter

The Swartwout Co.—Autronic thermocouple converter, an amplifier-converter unit which enables autronic system to be used with thermocouples or other low voltage dc input equipment, is described in bulletin A-712. Dimensions, mechanical and electronic specifications, and ranges are included.

Circle No. 100 on Reply Card

Cylinders for Electrohydraulic Circuits

Hydro-Line Mfg. Co.—An 8-page bulletin is devoted to Series J hydraulic cylinders. Tables covering bore sizes, rod, body and mounting dimensions are included. Mounting specifications are broken down to standard, foot, flange and swivel type installations. J cylinders are particularly applicable to electrohydraulic circuits to absorb the shock loads inherent in solenoid operated valves.

Circle No. 101 on Reply Card

Solving Pumping Problems

Geo. D. Roper Corp.—Discussion of general problems concerning rotary gear pumps precedes sample problem set-ups: how to operate a hydraulic cylinder; how to unload a tank car by general transfer; and how to supply oil burners by pressure transfer. Technical data include graphs on friction loss, cylinder displacement, and conversion tables (specific gravity, temperature, head to pressure).

Circle No. 102 on Reply Card

Automatic Invoicing

Remington Rand Inc.—"Application of the UNIVAC System to Invoicing" illustrates machine's ability to prepare invoices from the pricing to the final printing. Logical steps in invoicing as performed by machine, flow charts, sample forms, and equipment involved in the UNIVAC assembly make up a 24-page booklet.

Circle No. 103 on Reply Card

New Series of Potentiometers

DeJur-Amsco Corp.—Six basic models, with variations of each model available, form a new series of standard and power potentiometers for linear and nonlinear functions, as described in an 8-page bulletin. Some models feature indicated angles of rotation of 360° mechanical and 356° electrical to provide maximum resolution. Some have multiple ganged arrangements, shafts extended through either or both ends, self-aligning multiple finger brush contacts, and locking type shafts. Bulletin includes diagrams and specifications of most models.

Circle No. 104 on Reply Card

Variable Pitch Sheaves, Special Drives

Speed Selector Inc.—Illustrated 8-page bulletin describes variable pitch sheaves and special drives with dimensional and sectional drawings and charts. Typical applications illustrated are in conjunction with a punch press, a radial saw, an "iron lung" respirator, and a test stand for calibrating instruments. Useful table on how to select sheave size according to horsepower and motor speed included.

Circle No. 105 on Reply Card

Industrial Filtration

U. S. Hoffman Machinery Corp.—A complete line of industrial filtration equipment features disc filters; pressure filters for grinding, cutting and honing oil coolants, and industrial water; vacuum stills to reclaim oil-contaminated solvent; cartridge filters for by-pass operations; "Flomaster" filters for diesel lubricating oil; portable filters; "Vacumatic" filters for continuous filtration of coolants; flotation equipment for soluble oil coolants; separators and conditioners. Eight-page bulletin illustrates and describes each line and its adaptations.

Circle No. 106 on Reply Card

Pressure Transmitter

G. M. Giannini & Co., Inc.—A pressure transmitter for electrical output vs. pressure applications can be used to actuate telemetering or recording devices without amplification, to vary gain of or actuate controls in a servo system, and to produce high output mach number information by combining with another transmitter. Data sheet contains diagrams, structural and performance specifications, and a list of possible modifications for custom installations.

Circle No. 107 on Reply Card

Electrical Motors, Blowers, Fans

Mission-Western Engineers, Inc. — Bulletin describes approximately 50 basic miniature and subminiature electric motors, blowers, and fans in a general coverage of company's line of rotary electrical equipment.

Circle No. 108 on Reply Card

Switchboard Instruments

Weston Electrical Instrument Corp. — A group of switchboard instruments is available in ranges for any switchboard application, or for use in conjunction with tachometer generators, resistance bulbs and thermocouples, and high frequency thermoelements. Twelve-page catalog lists ac voltmeters, dc ammeters, polyphase and one-element wattmeters and varmeters, power factor meters,

new catalogs..... latest literature

Let us get them for you

frequency meters, and thermocouple instruments. Typical connection diagrams, full size scales and weights, dimensions and terminau markings are illustrated.

Circle No. 109 on Reply Card

"DO" Solenoid Valves

Eclipse Fuel Engineering Co.—Four-page bulletin offers photographs, dimensional drawings, specifications, and tables on a line of "DO" (diaphragm operated) solenoid valves. Valve is available in ⅜, ½, ¾, 1, 1¼, and 1½-in. sizes, contains only two moving parts—solenoid plunger and synthetic rubber diaphragm. Tables show selection of valves for 15, 30, 85, 125, and 150 psi pressure ranges.

Circle No. 110 on Reply Card

Continuous Peroxide Bleaching Range

Rodney Hunt Machine Co.—A new line of bleaching Rangettes, with capacities of 240 to 1500 lb per hour for small operations, is described with conventional rope and open-width bleaching ranges for large operations in a 28-page continuous peroxide bleaching range catalog. Text, photos, and drawings illustrate complete line of stainless steel equipment and components which can be incorporated into other bleaching ranges for improved efficiency.

Circle No. 111 on Reply Card

Motor Control Components Catalog

Furnas Electric Co.—Electric motor control catalog contains 140 pages of engineering and design data, including wiring diagrams and price lists, on more than 2700 items. Major classifications include magnetic starters and contactors, combination starters, control panels, drum controllers, and many types of switches.

Circle No. 112 on Reply Card

Mutiple Stage Flowmeter

Commercial Research Laboratories, Inc.—Design features, flow capacities, maintenance requirements, and mounting drawings of a new multiple stage flowmeter for the automotive, aircraft, chemical, and petroleum industries comprise a 4-page bulletin. Full size sections of individually graduated, 18-in. logarithmic scales, and a complete flow range chart listing maximum capacities of various stages, with or without a by pass orifice, are included.

Circle No. 113 on Reply Card

Stock Roller Chains and Sprockets

Diamond Chain Co., Inc.—Illustrated 64-page catalog covering a line of stock roller chains and sprockets is now available. Line includes minimum bore sprockets for reboring as well as finished bore and Taper-lock bushed sprockets which are ready to use. Chain selection and application data, charts, and prices included.

Circle No. 114 on Reply Card

Flow Controls

Hays Mfg. Co.—Four flow controls, to be used separately or in combination, are subject of an 8-page bulletin. "Electroflo" valve controls on and off flow of liquids; "Mesurflo" control delivers one set rate of fluid flow regardless of variable inlet pressures; "Straitflo" strainer is installed in the line, replacing union coupling, to provide strainer area in the flow way; and "Shur-Flo" automatic interlock protects equipment when flow is above or below predetermined limits by providing automatic cutoff or signalling.

Circle No. 115 on Reply Card

Compound Variable Speed Drives

Speed Selector Inc.—A new, countershaft type variable speed drive varies speed by changing its location between two fixed sheaves, has spring loaded belt face to maintain correct belt tension. Full load carrying capacity throughout speed range of 9 to 1 is assured. Four-page bulletin includes sheave size selection, and belt lengths and center distance tables, as well as installation and servicing instructions.

Circle No. 116 on Reply Card

Convertible Line Transfer Machine

Ferguson Machine & Tool Co.—Two basic models are available in a multiple station transfer machine which can be tooled and retooled to meet changing production requirements. For quick conversion to automatic assembly lines, machine adapts to light machining, forming, pressing, assembly and inspection operations at rates up to 20,000 pieces per hour. Precision cam indexing and many other features are described and illustrated in a 4-page bulletin.

Circle No. 117 on Reply Card

Controlled Proportioning System

Richardson Scale Co.—Booklet is available describing a remote controlled system for proportioning carbon blacks in rubber compounding operations. Study covers selection of ingredients and their weights, action of an automatic scale during weighing and discharging operations, and compensation for variations from preset weights. Stopping the process, repeating a cycle automatically, testing weighing accuracies, starting up after shutdown, and operating manually are also treated.

Circle No. 118 on Reply Card

Flexible Fractional HP Motodrive

Reeves Pulley Co.—Fractional horsepower vari-speed motodrive is available in ¼, 1/3, ½ and ¾-hp capacities; in speed ratios of 2:1 to 10:1; in vertical, horizontal, 45 degree and vertical shaft models; with speeds from 3 rpm to 4660 rpm; and with 112 different assemblies. Illustrated 24-page catalog lists operating and design features, instructions on how to select proper model, and list prices for all units, controls and modifications.

Circle No. 119 on Reply Card

"Build-it-Yourself" Terminal Blocks

Ilsco Copper Tube & Products, Inc.—Descriptive and colorful 4-page bulletin describes easily assembled terminal blocks which are built by owner to his individual requirements by simply putting together block housings, solderless lugs, and a locking strip. Strips can be assembled in sizes from one pole or circuit to 24 poles.

Circle No. 120 on Reply Card

Oxygen Control for "Cat" Crackers

Arnold O. Beckman, Inc.—Bulletin discusses continuous measurement of oxygen during regeneration of catalysts coated with carbon deposits. Efficient utilization and measurement of oxygen content of regenerator flue gases will eliminate losses due to reduced plant throughput, overloaded cyclones and precipitators, and increased compression costs. Equipment for such a system is listed. A supplementary bulletin describes sampling systems used with catalytic cracking regenerators and lists equipment.

Circle No. 121 on Reply Card

Temperature Monitoring System

Thermo Electric Co., Inc.—Eight-page bulletin illustrates a temperature monitoring system's method of handling a variety of temperature problems by using its components as building blocks, combined in different arrangements to adapt to requirements. Applications, operation details, and specifications are set forth.

Circle No. 122 on Reply Card

Engineering Special Test Equipment

Industrial Engineering Corp. — Four-page bulletin describes design and manufacturing facilities of these specialists in custom-built instrument panels, special test equipment, electrical and electronic devices, and switch gear. Typical installations which have been designed to customer's specifications are illustrated.

Circle No. 123 on Reply Card

Temperature Controller

Fenwal, Inc.—Series 560 temperature controller uses thermistor as sensing element, and combines on-off and proportioning control in one unit. Control range is 200 to 600 F; load circuit is 115v, 10 amp ac. Controller can be used for kilns, ovens, furnaces, extruding, air heaters, plastic packaging, injection molding and thermoplastic setting. Two-page brochure has photographs and specifications of model.

Circle No. 124 on Reply Card

Design, Build Special Equipment

York-Gillespie Mfg. Co.—Illustrated 4-page folder lists company's machine shop facilities and fabrication service with samples of special automatic and semiautomatic machinery it has designed and manufactured for the metal industry. Automatic 48-in. combination crosscut and drop saw and automatic forging manipulator are typical installations.

Circle No. 125 on Reply Card

Compact Geared Motor

Merkle-Korff Gear Co.—Geared motor with speed range of fractional to 700 rpm for use on industrial equipment and controls is described and illustrated in 4-page bulletin. Available in shaded pole, synchronous, series, and shunt models, motor features variety of mounting possibilities and maximum torque of 15 lb-in.

Circle No. 126 on Reply Card

Controlled Volume Pumping

Process Equipment Div., Lapp Insulator Co., Inc.—Line of Pulsafeeders is used primarily as pumps but easily adapts to chemical feeding, metering, filling, proportioning and sampling. Outstanding feature is lack of maintenance and corrosion due to combination piston-diaphragm design which eliminates necessity for stuffing box. Manually and auto-

New Catalogs & Literature

matically controlled models as well as special non-metallic and double diaphragm models for use with hazardous and exceptionally corrosive liquids are described in 24-page catalog.

Circle No. 127 on Reply Card

Diaphragm Operators, Valve Bodies

Minneapolis-Honeywell Regulator Co.—Butterfly valve bodies and diaphragm motor operators are described with complete tables of allowable pressure differentials in a 12-page bulletin. Dimensions, schematic drawings and selection tables on standard and heavy-duty butterfly bodies are featured, as well as data on spring and springless type diaphragm operators.

Circle No. 128 on Reply Card

Control Panels

Richardson Scale Co.—Weighing and materials handling systems, motor controls, machine tools, conveyorized sytems and plant processes are a few of the ideal adaptations for this line of control panels. Four-page bulletin pictures 27 typical panel installations in such industries as chemical processing, plastics and food processing.

Circle No. 129 on Reply Card

Miniature, Side-Mounting Connectors

DeJur-Amsco Corp.—Data sheet gives specifications on a line of miniature, side-mounting, reverse pin and socket connectors which are available in 2, 3, and 4 contacts. Voltage breakdown and schematic drawings are included. A new hexagonal hermetic plug with solid glass insulation for pressurized or sealed electronic equipment, available in 4, 5, 7, 9, and 10 contacts, is also described.

Circle No. 130 on Reply Card

Miniature Time Delay Relays

A. W. Haydon Co.—A data sheet is available describing and illustrating a line of miniature, hermetically-sealed time delay relays for use with either ac or dc units. Settings can range between two seconds and three hours. Schematic and wiring diagrams included.

Circle No. 131 on Reply Card

Power Transmission Components

Morse Chain Co.—Mechanical power transmission products are described in an eight-page bulletin which includes stock sizes, specications and applications for each product. Typical items are silent and roller chains, Hy-Vo drives, sprockets, cable chain, drive shafts, couplings and clutches.

Circle No. 132 on Reply Card

Modular Enclosure Systems

Elgin Metalformers Corp.—Stock individual units or assemblies of multiple units are available as attractive enclosures for control equipment and similar instrumentation. Units can be stacked on desks or are available in complete console assemblies. Panel area is 19 x 10½-in.

Circle No. 133 on Reply Card

Miniature Rigid Controls

Arens Controls, Inc.—New, miniature, rigid push-pull controls are available for manual reset operation of inaccessible controls, for direct transmission of motion in compact mechanisms, for power transmision through confined areas, and for remote indication. Two-page bulletin features engineering drawings and specifications.

Circle No. 134 on Reply Card

Data Processing Instruments

Consolidated Engineering Corp.—Entire line of data-processing equipment is covered in 12-page brochure. Photographs, technical specifications and descriptive functional diagrams supplement descriptions of instruments which are used in flight-test, field, production-line and laboratory use. Equipment discussed includes: recording oscillographs, galvanometers, amplifiers, power supplies, matching networks, velocity and pressure pickups, vibration meters, oscillogram processors and analog-to-digital converters.

Circle No. 135 on Reply Card

Oil Level Sight Gage

Century Hydraulics, Inc.—New oil level sight gage can be mounted on heavy or thin wall tank. Gage has steel stamped frame, plexiglass window, neo-cork gasket and wood shipping block. Two-page brochure includes mounting dimensions and photograph of gage.

Circle No. 136 on Reply Card

Operation Recorders

Bristol Co.—Line of electrical and mechanical operation recorders are subject of a new technical bulletin. Both round and strip chart models are available to record time of occurrence and duration of an operation. As many as 12 records can be made simultaneously on specific recorders. Applications include batch weighing on platform scales, automatic weighing, valve or gate operation, gas holder movement and position, and liquid level variation.

Circle No. 137 on Reply Card

Continuous Oxygen Analysis

Arnold O. Beckman, Inc.—Two bulletins discuss continuous oxygen analysis systems. The first describes analysis in the production of manufactured gas, inert purging operations, and safety applications where oxygen is the main contaminant. Recommended list of equipment necessary for analysis systems for industrial gas process streams included. Second bulletin describes operation of a sampling system for the dry gas samples found in many chemical applications.

Circle No. 138 on Reply Card

Instrument, Signal Source Generators

Electric Indicator Co., Inc.—A 24-page catalog has been issued on a complete line of permanent-magnet and wound-field dc, ac, and sine wave generators. Complete electrical and physical specifications are included with performance curves and dimensional drawings.

Circle No. 139 on Reply Card

Instrument Generator

Dalmotor Co.—Data sheet contains dimensional outlines, tabulates physical and electrical characteristics of a permanent magnet, continuous duty generator which is recommended as a precision voltage source. Operating parameters of phase voltage vs. load-per-phase are presented for speeds of 1200, 2100, and 4500 rpm giving frequencies of 20, 35, and 75 cycles per second.

Circle No. 140 on Reply Card

Indicator-Recorder for Feeders

Omega Machine Co.—Permanent record of volumetric dry feeder operation plus continuous indication of weight of material remaining in feeder hopper is achieved with a loss-in-weight indicator-recorder which is attached to the feeder. Data sheet gives complete details, dimensions and specifications.

Circle No. 141 on Reply Card

High Pressure Filters

Trabon Engineering Corp.—Dimensions and comprehensive data charts on performance and structure of high pressure lubrication filter systems are published in this data sheet. Filters withstand 1000 psi working pressure and 1800 psi test pressure.

Circle No. 142 on Reply Card

Electrical Indicating Instruments

Hickok Electrical Instrument Co.—Comprehensive 48-page catalog of indicating instruments, laboratory portables and panel meters features illustrations and specifications on round, square, flush, semiflush, switchboard, horizontal edgewise, fan type, 250° arc-angle sealed and "ruggedized" meters. Ammeters, decibel meters, frequency meters, microammeters, milliammeters, millivoltmeters, voltmeters, wattmeters, shunts and transformers are typical listings.

Circle No. 143 on Reply Card

Bracket Mounted Lamp Sockets

Dialight Corp. — Catalog lists variety of bracket mounted sockets for small lamps such as those used for indicator service. Mounting diagrams for numerous models of double contact bayonet sockets, candelabra screw, intermediate screw, miniature screw, and miniature bayonet sockets are given in 22 pages as well as a selection of lamps, navy specification and specialty sockets.

Circle No. 144 on Reply Card

Universal Automatic Chucker

National Acme Co.—Single spindle, universal, 12-in. automatic chucking machine is described fully in a 12-page illustrated bulletin. Chucker can be used with carbide and high speed tools, has spindle speeds of 25 to 1478 rpm. Diagrams, dimensional drawings, specifications, and examples of applications supplement text.

Circle No. 145 on Reply Card

Parts Handling Wire Baskets

Wire & Iron Products Inc.—Standard or custom engineered baskets of wire, wire mesh, expanded or perforated metal are said to assure greater efficiency in parts handling and storage. "Ezy-stak" baskets can be constructed with individual compartments or racks to protect precision finishes of parts. Many units illustrated in a new 4-page bulletin.

Circle No. 146 on Reply Card

Automated Plating

Wagner Bros., Inc.—Fully automatic plating machine features a unique parts transfer and conveying principle which permits efficient processing of parts through plating cycle. Six-page bulletin illustrates the basic movements, offers details on component controls, power package, accessory hydromotors, reciprocating carriage and work lifting arms, and agitation mechanism.

Circle No. 147 on Reply Card

Automatic Controls

Seely Instrument Co., Inc.—Semi or fully automatic operation of present machinery is possible with use of Aeromac timers, temperature and pressure controls, and air diaphragm motor valves used singly or in combination. These controls may be adapted to manually controlled hydraulic compression presses, batch machinery, or cyclical operations. Bulletin stresses adaptation to molding, pressing, extrusion, centrifuging, and testing processes, and to conveyor cycling.

Circle No. 148 on Reply Card

Liquid Level Control

Minneapolis-Honeywell Regulator Co. — A dozen systems for measuring and controlling liquid level, starting with Archimedes' ball float and ending with the Atomic Age's use of gamma rays, are covered in a 24-page bulletin. Sections on remote transmission and automatic control of liquid levels, hydrostatic pressure, displacement, and electrical conductivity systems are included. A two-page tabulation of 12 systems offers quick comparison. Special section is devoted to handling of difficult liquids.

Circle No. 149 on Reply Card

Heat-Flow Transducer

Beckman & Whitley, Inc.—Ideal for application to all instrumentation set-ups which require directly driven indicating or recording meters, a climatic survey heat-flow transducer is made up of many closely connected thermocouple junctions. Bulletin gives calibration curves, dimensions and specifications.

Circle No. 150 on Reply Card

Protection Against Vibration

Beta Corp.—Vibraswitch, a vibration measurement and warning device, is completely described with specifications and diagram in a 4-page bulletin. Installed on any rotating or vibrating machine, this device can actuate a warning or automatically shut down the machine when vibration exceeds safety limits. Vibration nomograph shows relative cycles per second frequency and inches per second velocity.

Circle No. 151 on Reply Card

Proportional Air and Gas Mixers

Eclipse Fuel Engineering Co.—A complete line of air or gas proportional mixers for mixing gaseous fuels with air or oxygen in the proper ratio for gas burner systems is described in a 4-page bulletin. Tables show percentage of heat loss due to excess gas or air, and complete list of mixing devices includes injectors, proportionators, and diluters.

Circle No. 152 on Reply Card

Linear Accelerometers

Statham Laboratories, Inc.—Descriptive bulletin offers sketches and dimensions on most common of a large line of linear accelerometers for static and dynamic measurements. Units operate on ac or dc circuit for use with a wide range of recording, telemetering and controlling systems. Possible variety in ranges and resistances is unlimited.

Circle No. 153 on Reply Card

Two-Lever Coordination Control

Pantex Mfg. Corp.—An eight-page file of application engineering data on a new two-lever coordination control has been assembled for those interested in safety, control and operating devices for pneumatically actuated equipment. In addition to description and illustrations, complete specifications, capacities, operating forces, mounting data and prices are listed.

Circle No. 154 on Reply Card

Electronic Relay of Medium Sensitivity

Machinery Electrification, Inc. — Electronic relay is compact and inexpensive, is recommended for stop-motion applications, gaging operations, for controlling various devices from contact making instruments. Provision for "lock-in" operation is made. Maximum sensitivity is 1 megohm. Series of data sheets contains description, specifications, illustrations, price lists, and interesting "doodle" sheet of engineering notes on the relay.

Circle No. 155 on Reply Card

Dry-Type Transformers

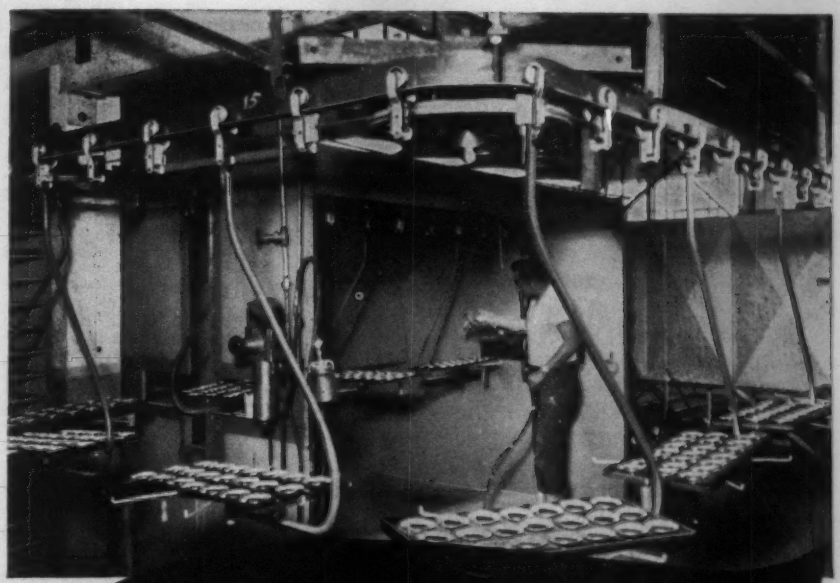
Harrison Transformer Corp.—Catalog suggests proper applications for each of a line of dry-type, air-cooled transformers. Each model is illustrated, has descriptive data, schematic diagram, dimensions and list price. Used for industrial and commercial lighting and power circuits, transformers are available in ratings of 600 v or less, from 0.1 to 200 kva single-phase, or 15 to 300 kva three-phase.

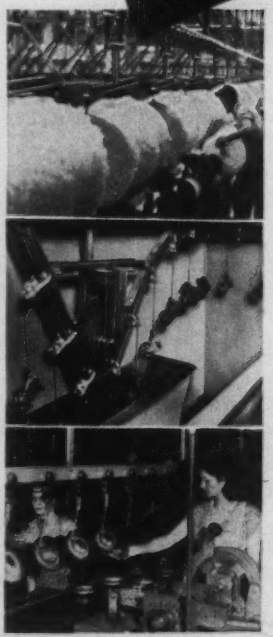
Circle No. 156 on Reply Card

Study of Industrial Oil Conditioning

Industrial Filtration Div., U. S. Hoffman Machinery Corp.—Sixth in a series of case histories, this 4-page bulletin describes the use of oil conditioners in electric power generating plants and distributing centers, and in pumping stations of oil pipelines. Filter-vaporizer combination is used to reclaim lubricating and transformer oils, assures operating economy and stable oil viscosity.

Circle No. 157 on Reply Card





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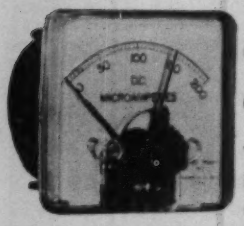

RANGES:

0/20 Ua. to 0/50 A.
0/5 Mv. to 0/500 V.

The trip point is adjustable to any point on the scale arc. These meter-relays are sensitive to changes of as little as 1%. One contact is carried on moving pointer. The other is on a semi-fixed pointer. When two pointers meet contacts close and lock. Holding coil is wound directly over moving coil. Reset can be manual or automatic. Spring action in contacts kicks them apart forcefully. Three sizes of clear plastic case models, 2½, 3¾ and 4½ inches (all rectangular). Two ruggedized and sealed models, 2½ and 3½ inches (round metal cases). Contact arrangements: High Limit Single, Low Limit Single or Double (both high and low). Contact rating is 5 to 25 milliamperes D.C.

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Correction Transmission

Machine-O'Matic, Inc.—Photoelectric cell, in conjunction with a selector switch detects errors and transmits information to correction motor which operates correction transmission. Four-page brochure discusses photoelectric scanner, selector switch and correction motor which are components of two-way correction unit. System is applicable to imprinting machines, bag machines, sheet cutters, collating machines, punch presses, die cutting machines, and others.

Circle No. 158 on Reply Card

Variable Ratio Transformer

Perkin-Elmer Corp.—Six-page brochure explains construction and operation of precision variable ratio transformer called "Vernistat". Unit is said to combine resolution and linearity associated with multiturn potentiometers with a low output impedance. Included in brochure are performance curves, application schematics in computer and servosystems, and specifications of the 60 and 400 cps types.

Circle No. 159 on Reply Card

Program Control Systems

Leeds & Northrup Co.—Information on program control systems which offer flexibility in setting rate of heating, length of soak period and rate of cooling in batch-type heating process is given in two-page bulletin sheet. Equipment required for each of five basic programing cycles and general equipment essential to a two-position or proportioning type program control system is also covered.

Circle No. 160 on Reply Card

Miniature Recorders, Controllers

Industrial Div., Minneapolis-Honeywell Regulator Co. — Twelve-page bulletin outlines miniature recorders and controllers which are designed for accurate recording and control of process variables such as temperature, pressure, flow and liquid level. Instruments have high sensitivity, instant response to process change, and a pneumatic balance operating principle. Photographs, specifications and applications of instruments are included.

Circle No. 161 on Reply Card

Digital Instruments

Brush Electronics Co.—Four-page folder describes five related digital instruments for automatic counting, recording, and control. Digital systems are applicable in industry for quality control, process control, packaging, production testing and gaging. Five units described are cycling counter, time interval meter, combination counter-timer, preset timer and recording unit.

Circle No. 162 on Reply Card

Ball Bearing Trolleys

Link-Belt Co.—Ball bearing trolleys for overhead conveyors are discussed in 20-page bulletin. Trolleys are for use on 3, 4, or 6-in. I-beams, and are available in two types; bolted wheel and bracket assembly, and riveted. Ball bearings have ground raceways to keep friction at a minimum and provide long life. Bulletin contains specifications data, applications and maintenance information.

Circle No. 163 on Reply Card

Package Boiler Control

Hays Corp. — Automatic electric metering packaged control for water tube packaged boilers is the subject of four-page brochure. Schematic drawing of typical packaged control system for a combination oil and gas fired boiler is given. Components of the system—metering control, off-on control, safety cutout switches, valves, electric switches, indicating gages and recorders—are described.

Circle No. 164 on Reply Card

Industrial Cells

Ohmart Corp.—Eight-page brochure describes line of cells, developed for direct conversion of radioactive energy to electrical energy. Sells are self generating and do not require high voltage source of excitation. Also discussed are gravity meters and level gages, along with photographs and specifications of equipment.

Circle No. 165 on Reply Card

Industrial Control Counters

Potter Instrument Co., Inc.—Detailed descriptions of equipment and techniques for controlling industrial equipment by means of predetermined counters are given in 20-page booklet. Equipment described includes counters capable of being preset to apply control after any desired number of counts from 1 to 1,000,000 and a complete line of count detectors for converting physical increments into electrical impulses for counting.

Circle No. 166 on Reply Card

Wiring Connectors

Ilsco Copper Tube & Products, Inc.—Comprehensive 73-page catalog describes company's wire connectors, including automotive lugs, set screw connectors, terminals and switch blades. Photographs, specifications, and applications of all equipment are included.

Circle No. 167 on Reply Card

Centrifugal Blowers, Exhausters

Air Appliance Div., U. S. Hoffman Machinery Corp.—Multistage blowers and exhausters are designed for applications requiring air pressure from 1 to 9 psi, or vacuum from 2 to 12 in. of mercury. Equipment will deliver air at uniform pressure regardless of variations in volume. Twelve-page bulletin describes several models and contains charts showing capacity ranges of blowers and exhausters.

Circle No. 168 on Reply Card

Instrument Gearing

Feedback Controls Inc.—Eight-page brochure covers precision line of gear heads, gear trains and speed reducers. Gear trains are designed for use in analog computers and high performance electromechanical systems. Complete description of precision equipment includes photographs and specifications data.

Circle No. 169 on Reply Card

Pressure Recorders

Foxboro Co.—Line of pressure instruments designed for direct measurement, remote transmission and automatic control is described in 24-page bulletin. Application chart shows choice of element materials available, such as stainless steel and beryllium copper. Bulletin describes case and linkage features, lists charts for standard process ranges and covers accessories such as seals and pulsation dampeners.

Circle No. 170 on Reply Card

Cam Clutches

Morse Chain Co.—Eight-page brochure and four illustrated catalog sheets comprise reference file on line of cam clutches for indexing, overrunning and backstop applications. Cutaway photographs of clutches, operating functions, design features and general information are included. Installation procedures and lubrication information are also given.

Circle No. 171 on Reply Card

Hand and Foot Operated Valves

Ross Operating Valve Co.—Twenty-page bulletin describes series of valves. Installation data, parts lists and photographs showing assembly relationship between parts are included. Valves feature wide variety of levers and treadles and do not require disconnection of piping for replacement. Colored air flow diagrams are given in bulletin.

Circle No. 172 on Reply Card

Fluid Power Cylinders

Modernair Corp.—Four-page brochure describes line of fluid power cylinders, valves, and packaged devices. Among cylinders illustrated are threaded-head type with interchangeable mounting brackets, coaxial air/hydraulic and air return cylinders. Picture page showing application of company products is included.

Circle No. 173 on Reply Card

New Catalogs & Literature

Temperature Measurement Control

Minneapolis-Honeywell Regulator Co.—Catalog 6709 lists thermal and control systems for temperature measurement applications. Recording thermometers for special purposes, pneumatic and electric control programming, bulbs, fittings and tubing are thoroughly treated. Charts and scale selection data, as well as information on valve applications are included in 44 pages.

Circle No. 174 on Reply Card

Bimetal Disc Thermostats

Stevens Mfg. Co., Inc.—Two-page brochure describes line of thermostats for electronic and avionic devices, appliances and apparatus. Thermostats are hermetically sealed and respond only to heat from controlled devices or air surrounding the thermostat. Bulletin gives performance data, ratings, dimensions, construction details and includes photographs of various mounting arrangements.

Circle No. 175 on Reply Card

Turning Machine

Monarch Machine Tool Co.—Twenty-seven page bulletin discusses company equipment including various models of lathes, hand screw machines, form turning machines, heavy duty roll turners, and engraving machines. Photographs, specifications and applications of all equipment are included.

Circle No. 176 on Reply Card

Selenium Rectifiers

Fansteel Metallurgical Corp.—High temperature selenium rectifiers which are designed to operate continuously at room temperature ratings in ambient temperatures up to 100C are discussed in four-page brochure. Brochure lists 86 types and sizes of high temperature rectifier cells, their dc output ratings in various single phase and three phase circuits, life and aging characteristics, voltage drop, circuit formulae and constants, and protective coatings.

Circle No. 177 on Reply Card

Precision Instrument Components

PIC Design Corp.—Sixty-four page catalog illustrates line of precision shafts, gears, collars, couplings, differentials, breadboard equipment, etc. All items in catalog are completely dimensioned for design and detail layout. Tolerance specifications of components are also given. Precision instrument parts and mechanical components discussed have been standardized by the company.

Circle No. 178 on Reply Card

Air Grip Clutch

Dodge Mfg. Corp.—Air grip clutch which features finger-tip control, built-in quick release valves, and minimum air volume requirement is discussed in four-page brochure. Clutch operates at air pressures up to 150 psi and is internally ventilated for cooler operation. Brochure includes information on air control and release valves, tabular data on clutch sizes, dimensions, bore sizes, weights and lists prices.

Circle No. 179 on Reply Card

Maintenance of Electrical Controls

W. F. & John Barnes Co.—Wired-in checking systems consisting of separate electrical circuits wired to schematic electric diagrams have been designed to meet the problem of service and maintenance in designing and building automation equipment. The systems, called "electro-graphic detectors," fit a wide variety of mass production applications where machine downtime resulting from electrical control failures may impair plant efficiency. Line drawings and photographs showing the general design details of individual panels and description of test procedures are included in eight-page brochure.

Circle No. 180 on Reply Card

Industrial Baskets, Tanks, Trays

Wiretex Mfg. Co., Inc.—A variety of wire mesh carriers for dipping, pickling, anodizing, cleaning, plating, and heat treating processes is described in a new 12-page catalog. Baskets come in different sizes, meshes, and alloys to best adapt to each particular application. Company will design to customer's specifications from stock of raw materials.

Circle No. 181 on Reply Card

Potentiometer Linearities

Clarostat Mfg. Co.—Definitions of four types of linearity—independent, zero based, terminal and index point—which potentiometer applications demand, are given in illustrated bulletin. Material is intended to aid in selection of linearity types, and includes pictorial output of each type of linearity.

Circle No. 182 on Reply Card

Multiwall Bag Conversion Equipment

Potdevin Machine Co.—Multiwall tubing machinery, two and four color oil-ink printing equipment, sleeve valvers, valvers, sewing machines and conveyors are discussed in eight-page brochure. Specifications and illustrations of all equipment are given. Also included is a floor plan for sewed-end multiwall bags.

Circle No. 183 on Reply Card

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S-14-A HIGH GAIN POCKETSCOPE
S-14-B WIDE BAND POCKETSCOPE
S-15-A TWIN TUBE POCKETSCOPE
RAYONIC® Cathode Ray Tubes
and Other Associated Equipment

Spring and Springless Operators

Minneapolis-Honeywell Regulator Co.—Complete descriptions and schematic drawings of spring and springless types of Air-O-Motor operators are given in an 8-page bulletin. Thrust and lever type models in both types are included. Charts giving all available forces based on changes in air pressure, and variance of forces at different stages of stroke for each size motor, are included.

Circle No. 184 on Reply Card

Voice Frequency Channels

Motorola Communications and Electronics, Inc.—Method of expanding usefulness of a voice communications channel so that it is capable of transmitting 2 to 18 times as much intelligence is given in 12-page bulletin. Bulletin tells how to use the upper portion of the voice frequency spectrum to send control and data reporting signals over five channels without affecting the voice transmission. Photographs and drawings illustrate how frequency-shift voice frequency carrier can be used in many communications networks where data can be translated into coded information.

Circle No. 185 on Reply Card

Temperature Controls

Burling Instrument Co.—Three models of temperature controls, each of which is dual, are described in two page bulletin. Each model incorporates two independent electric switches for operation up to 1800F. Models differ in type of enclosure—standard, weathertight or explosionproof. All operate by differential expansion of solids and use no filled bulb or capillary tubing. Bulletin is fifth in a series.

Circle No. 186 on Reply Card

Automatic Bag Making and Filling

Simplex Packaging Machinery, Inc.—A fully automatic packaging machine can make a bag, weigh or measure the product, fill and seal the bag, and check the entire package in one continuous operation. Four-page bulletin gives complete details and lists optional packaging attachments for this unit, called Simplex-O-Matic.

Circle No. 187 on Reply Card

Pressure Transmitter

Swartwout Co.—Two-page data sheet describes flush diaphragm pressure transmitter which is designed to operate in conjunction with recording and/or controlling elements of the automatic control system. No motors, boosters, slide wires or vacuum tubes are used in transmitter. Diaphragm fits flush with the inside of the process pipe. Bulletin is illustrated with a cutaway view and dimensional diagram of the transmitter.

Circle No. 188 on Reply Card

Millivoltmeter Pyrometers

Bristol Co.—Twelve-page brochure discusses new line of millivoltmeter pyrometers and accessories. Included is material on indicating pyrometers for service up to 4000F, indicating controllers with mercury switches, two-point and multiple-point pyrometer switches for use when a single indicator is intended to monitor temperature measurements for more than one station. Photographs of models are included in the bulletin.

Circle No. 189 on Reply Card

Flow Meters

Minneapolis-Honeywell Regulator Co.—All types of flow meters, evenly graduated and square root graduated types, are discussed in a 56-page catalog, No. 2320. Electronic integrators, electric and pneumatic transmitters, and pneumatic controllers for application with meters, as well as mercuryless and area type (for viscous liquids) meters are covered. Dimensions and installation information on systems included.

Circle No. 190 on Reply Card

Solenoid Contactors

Guardian Electric Mfg. Co.—Wide range of enclosed and sealed model solenoid contactors with power range up to 250 amp are covered

in six-page bulletin. Contactors are tested to operate in all positions under accelerations exceeding ten times gravity, at altitudes up to 50,000 ft. Bulletin is fully illustrated and includes dimensional drawings and complete technical data.

Circle No. 191 on Reply Card

Unidirectional Motors

Barber-Colman Co.—Motors designed for use in driving pumps, fans and blowers, record changers, vending machines and industrial controls are discussed in four-page bulletin. Standard motors can be supplied with either high starting torque rotor or high running torque rotor and in four stack thicknesses. Ratings up to 1/20 hp at 3000 rpm are available. Photographs and performance curves of motors are included.

Circle No. 192 on Reply Card

Copper Clad Plastic Laminates

Richardson Co.—Four-page bulletin describes and gives specifications for two grades of copper clad laminates for use in printed circuits and for such printed components as capacitors, inductances, and resistors. These are high quality, paper-base phenolic laminates bonded to copper foil of 0.0014 and 0.0028-in. thickness.

Circle No. 193 on Reply Card

Telemetering Equipment

Automatic Control Co.—Remote transmission systems for water, sewage and process plant uses are the subject of an eight-page brochure. Brochure defines telemetering, basic types of telemetering equipment, and discusses five models—one-step, two-step, two-step with reporting signal, multiple step and proportional multiple step. Photographs and charts are included in the bulletin.

Circle No. 194 on Reply Card

Controls for Automatic Scales

Richardson Scale Co.—Technical reference is available describing indicating and recording systems for use with standard scales. In addition to description of sequence of operation in the weighing, indicating and recording processes, bulletin discusses time delay before full-balance printing, partial draft printing and provisions for recording time and date.

Circle No. 195 on Reply Card

Digital Instruments

Brush Electronics Co. — Four-page folder describes five related digital instruments for automatic counting, recording and control. Digital systems are applicable in manufacturing for quality control, process control, packaging production testing and gaging. Five units described are cycling counter, time interval meter, combination counter-timer, preset timer and recording unit.

Circle No. 196 on Reply Card

Liquid Chemical Feeder

Fischer & Porter Co.—Specifications, capacities, installation diagrams, and applications of a small, inexpensive feeder for metering, controlling, mixing, and dispensing small quantities of liquid chemicals are included in a data sheet. "Feedrator" feeder contains a built-in ejector which eliminates need for a proportioning pump.

Circle No. 197 on Reply Card

Application of Vacuum Furnaces

F. J. Stokes Machine Co.—A twelve-page booklet discusses use of vacuum furnaces in melting and casting new metals such as titanium, zirconium, and germanium, as well as in sintering, annealing, hardening, brazing, and degassing. Descriptions and drawings of several types of vacuum furnaces are included. These include resistance-heated furnaces with movable heat source, tilting type furnaces, and movable-retort furnaces.

Circle No. 198 on Reply Card

Low Pressure Air Burner

Hauck Mfg. Co.—Catalog 413 features a new vari-pressure low pressure air type burner designed for multiple burner applications where automatic ratio and control of air and oil capacities is desirable. Burner uses oil, or oil and gas combined, has flame adjusting lever. Industrial applications are to forging, annealing, billet heating, and heat treating and melting furnaces.

Circle No. 199 on Reply Card

High-Impedance Input

Minneapolis-Honeywell Regulator Co.—ElectroniK high impedance instrument for source impedances from 0 to 50,000 ohms is subject of data sheet 10.0-14. Requiring no dc preamplifier, the unit may be employed for corrective action with minute error signals, for null detection with bridge or potentiometer circuits where encountered spans are narrow, for measurement of limited current. Amplifier with input transformer may be used without special input filter for high impedance ac applications such as null-balance servo loops.

Circle No. 200 on Reply Card

Automatic Screw Machines

National Acme Co.—Five models of single-spindle automatic screw machines which handle bar machine work from ⅛ to 2 in. round are described in 4-page folder. Machines feature automatic lubrication and accessible camming and tooling as well as automatic operation. Description includes individual specifications for each machine, capacity chart, and lists of standard and extra equipment.

Circle No. 201 on Reply Card

Electroplating Industry Rectifiers

Wagner Bros., Inc.—Rectifiers with capacities of 5 to 50,000 amp, their regulators and controls, for electroplating equipment are listed in an 8-page bulletin. Reversal and interruption units and programming controls are included with description of company facilities and services.

Circle No. 202 on Reply Card

Centerless Grinder

Landis Tool Co.—Precision centerless grinder is available in two models for through-feed or infeed grinding of large or small quantities. Four-page bulletin describes machines, and furnishes specifications and lists of standard and optional equipment.

Circle No. 203 on Reply Card

Automatic Gas, Oil Burner

Peabody Engineering Corp.—Oil, gas, or combination firing burner is completely automatic in operation, and features automatic fuel to air ratio control and capacity control as well as many safety controls. Capacities up to 42,000 lb steam per hour can be handled satisfactorily, as described in 4-page bulletin.

Circle No. 204 on Reply Card

Packaged Steam Generators

Union Iron Works—Water tube steam generators are delivered completely assembled and ready to fire oil, gas, or both. Available in 13 sizes to handle from 10,000 to 40,000 lb steam per hour, generators can be operated automatically (with automatic ignition and combustion controls), semi-automatically (with combustion control only), or manually. Illustrations and dimension tables included in a 16-page bulletin.

Circle No. 205 on Reply Card

High Voltage Connector

DeJur-Amsco Corp. — Data sheet contains schematics, mechanical and electrical ratings, photographs, and detailed description of new continental, six contact connector for high voltage operations. Ideal applications include voltage breakdown of 4000 v rms at sea level, of 1800 v rms at 60,000 ft.

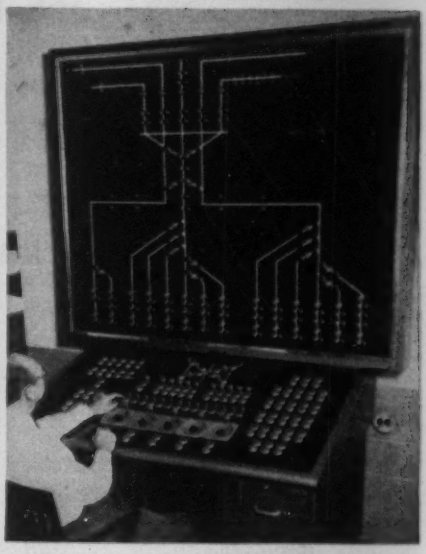
Circle No. 206 on Reply Card

Abrasive Kilns

Eclipse Fuel Engineering Co.—Car-bottom kilns have flexible program control and uniform heating up to 2400 F. Furnaces are designed for firing abrasives.

Circle No. 207 on Reply Card

WHAT'S *NEW* ABOUT Automation?



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AUTOMATION

ABSTRACTS

CONTROLLING AFTERBURNER TEMPERATURE

G. R. DESI and C. F. WOOD
Westinghouse Electric Corp.
Philadelphia, Pa.

AUTOMATIC temperature controls are now used on many high performance turbojet engines. Since these controls are electrical, special design methods are required to achieve a degree of reliability acceptable to the aviation industry.

As time has gone on, various changes have been made to jet engines to increase their performance. There has been a marked increase in compressor pressure ratio—this has increased engine efficiency and thrust. Addition of an afterburner provides a further increase in the thrust range available from a given engine. However, the afterburner requires its own fuel pumping and control means and a means for varying the exhaust nozzle area. Thus, by use of the afterburner, two additional control systems are required each as complicated as the basic engine fuel control.

Tests have shown that in order to operate an afterburner at maximum performance, the basic engine must be kept running at its maximum output during all afterburning operation. To do this, both the engine rpm and the turbine outlet temperature must be held constant. Engine rpm is set by a governor which regulates fuel flow to the basic engine. The turbine outlet temperature will then be controlled by a combination of the afterburner temperature rise and the exhaust nozzle area.

Since gas flow to the afterburner is set by the engine, maximum thrust is obtained at maximum burner temperature rise. At each flight condition, the maximum burner temperature rise occurs at a given fuel-gas ratio. Thus, in order to operate the afterburner at maximum thrust, a fixed afterburner fuel flow is required. The exhaust nozzle area then is the only independent variable left to regulate turbine outlet temperature.

One of the effective ways of setting correct exhaust nozzle area is the use of an automatic temperature control system. By using an automatic turbine outlet temperature control, both the military and the afterburning thrusts can be raised appreciably in many flight conditions without jeopardizing engine safety for overall operation.

A maximum safe turbine outlet temperature is established for each engine model as the result of exhaustive testing. If this safe temperature is exceeded, life of the turbine is drastically reduced —an increase of 100F may shorten the life to one-tenth of its normal value. To fall below the limit reduces thrust output of the engine—1 per cent in thrust being lost for every 10F reduction in temperature.

Nozzle Control

In order to obtain high performance, the modern afterburning turbojet engine is equipped with a number of separate but interconnected control systems. These are the basic engine fuel control, the afterburner fuel control, and the exhaust nozzle control. For the engine to perform properly, each of these controls must be functioning separately and in co-ordination in the prescribed manner. A failure in any one of them will have more or less serious consequences to the operation of the engine. Thus, the control design engineer is faced with some very exacting problems of design and construction for highly reliable operation.

During all operation of current Westinghouse production afterburning engines at thrusts above 50 per cent military rated, the engine rpm is held constant at its maximum value by the top speed governor. From 50 to 100 per cent military rated, the thrust is varied by modulation of the exhust nozzle area alone. In the afterburning thrust range, thrust is varied by modulating afterburner fuel flow. The temperature control adjusts the exhaust nozzle area as required to keep the basic engine operating at maximum output.

For the present discussion, we will consider operation of the engine at or near military thrust and during afterburning, only. In both these regions, the temperature control is arranged to reduce the exhaust nozzle area below that set by the basic exhaust nozzle control. The amount of area reduction depends upon the amount of correction which is required under a given flight condition.

For purposes of flight safety, the minimum exhaust nozzle area which can be produced by the temperature trim function is limited. The limit is set so that under the flight condition which requires the smallest exhaust

nozzle area, the temperature control is just capable of producing rated turbine outlet temperature. It should be noted that the area limit for afterburning is different from that for military operation.

A schematic of the exhaust nozzle control system is shown in *Fig.* 1. The exhaust nozzle is positioned by a hydraulic servosystem which receives its signals from a mechanical computer. The mechanical computer has a basic function which is operative under all conditions and which calls for exhaust nozzle areas which are determined by the position of the power lever only. In addition to the basic function, there are a number of secondary functions which are necessary to obtain good engine operation. One of these secondary functions is that of trimming the exhaust nozzle area from temperature control signals.

The other secondary functions provide for proper sequencing of the control during accelerations and during initiation and termination of afterburning by means of over-rides on the computer. Although all computing is done mechanically, it has been necessary to use electrical signals to control the secondary functions. Electrical control circuits are arranged to make secondary functions inoperative in case of electrical failures. When all secondary functions are inoperative, the basic function takes full command of the exhaust nozzle area.

Exhaust nozzle area established by the basic control function, when the power lever is placed in the military position, will cause the engine to produce military thrust under sea level static hot day conditions. Under these same operating conditions, placement of the power lever in the takeoff, or full afterburning, position will cause the engine to produce the maximum afterburning thrust.

With this design philosophy and because the basic servosystem is of a high order of reliability, the entire exhausting nozzle control system is considered to have excellent failure characteristics. This does not, however, relieve the temperature control designer of any responsibility for providing the most reliable temperature control.

The temperature control is shown in block diagram form in *Fig.* 2. The thermocouples produce an electrical signal proportional to the turbine outlet temperature. This signal is compared to the voltage from the temperature reference. The difference between these two signals, or error signal, is sensed by the error detector. The error detector, or Microsen is a galvanometer-type instrument. The error amplifier senses the Microsen beam position electrically and thereby produces a voltage proportional to the error signal.

For small signals, the proportionality between the error signal and the output voltage of the error amplifier is assured by the error feedback network. Without feedback, the error detector and amplifier combination produces a gain of approximately 100,000. With the feedback network operative, the gain is reduced to approximately 2500. With this feedback, a two to one change in amplifier gain produces only a 2½-per cent change in amplifier output.

Error amplifier output passes through a directional network and then to a servoamplifier and trim motor which is mechanically coupled to the exhaust nozzle computer. The feedback network around the motor and amplifier is provided to obtain required motor response characteristics.

Design Requirements

To assure adequate control of the engine, definite requirements were established for the performance of

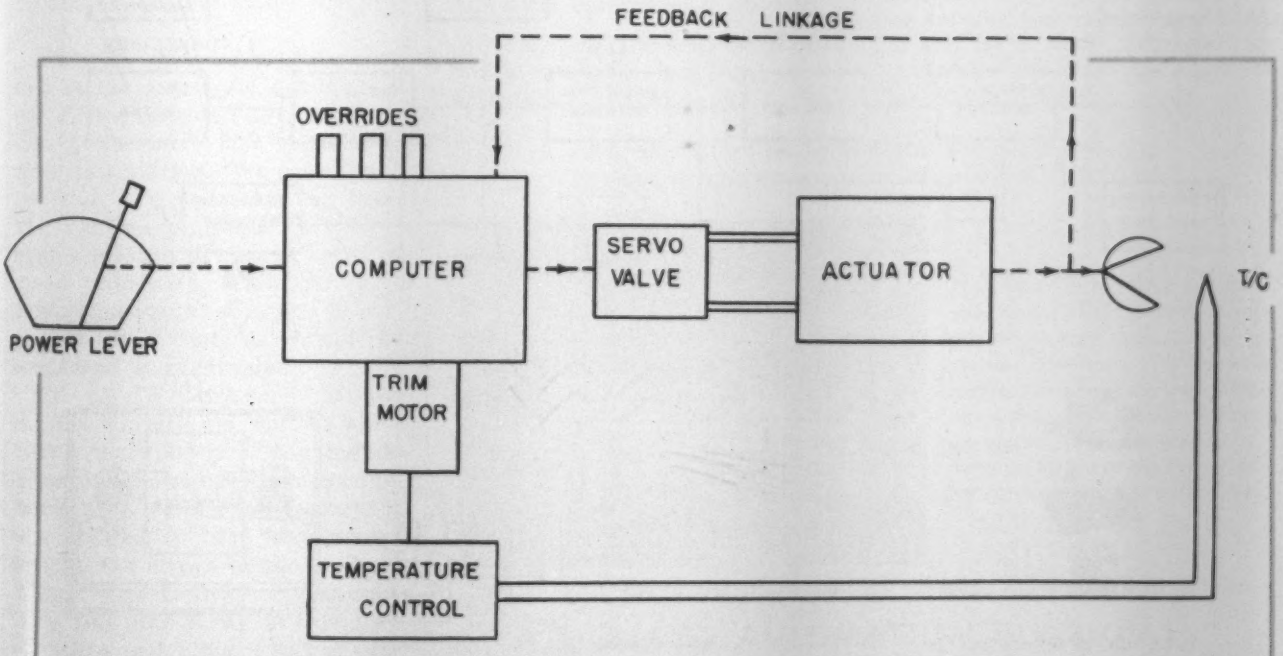


Fig. 1—Exhaust nozzle is positioned by a hydraulic servosystem which receives its signals from a mechanical computer. Input to the computer is received from the position of the power lever as a basic function and a number of secondary functions one of which is turbine outlet temperature

the temperature control. These requirements cover both transient and steady state operation. For the purposes of this discussion, transient operation covers the period immediately after the power lever is moved rapidly into either the military or afterburning thrust positions. Transient operation is considered to last for a maximum of about 30 seconds. Steady-state operation covers the period from the end of one transient to the beginning of the next. Steady-state operation assumes constant flight conditions.

The following requirements apply to performance of the engine-control combination immediately following a rapid motion of the power lever into either military or afterburning thrust positions, provided the engine is at maximum rpm:

1. Turbine outlet temperature not more than 40F above its set value for more than two seconds.
2. Turbine outlet temperature never exceeds its set value by more than 100F.
3. Not be more than two cycles of oscillation of the turbine outlet temperature visible on the standard test cell instrumentation after the indicated temperature first reaches its set value.
4. Turbine outlet temperature within 20F of its set value within 20 seconds after the initiation of the transient.

The following requirements apply to the steady-state performance of the engine-control combination:

1. When the power lever is placed in the military or the maximum position, the temperature control shall maintain the turbine outlet temperature of the engine within ±20F of the desired temperature under all flight conditions within the operating limits of the engine.
2. At power lever positions below military the tolerances on the temperature control become wider the further the power lever is moved from the military position.

These performance requirements are well considered items which have been worked out over a considerable period of time. Each one of them represents some compromise between the desires of the control designer and those of the engine designer.

If asked whether an electrical control can be made as durable as a good hydraulic or mechanical control, most mechanical engineers would reply, "Certainly not!" The difference in durability is, however, not so great as would be imagined. With proper design, electrical components can be made almost as durable as desired, limited only by space and weight considerations.

We can illustrate the approach to proper design which follows from a knowledge of operating conditions with the case of electron tubes. Electron tubes are generally considered the most unreliable of electrical components. The number of tube failures on production units, however, has been negligible.

The important condition in the case of electron tubes is the destructive power of engine noise. This is true not only for tubes, but for sensitive relays and galvanometer type instruments as well. It was found that these sensitive components were unaffected by the engine noise until they were mounted on a sounding board. In all cases, the solution was the same. Isolate all sensitive components from the sound-

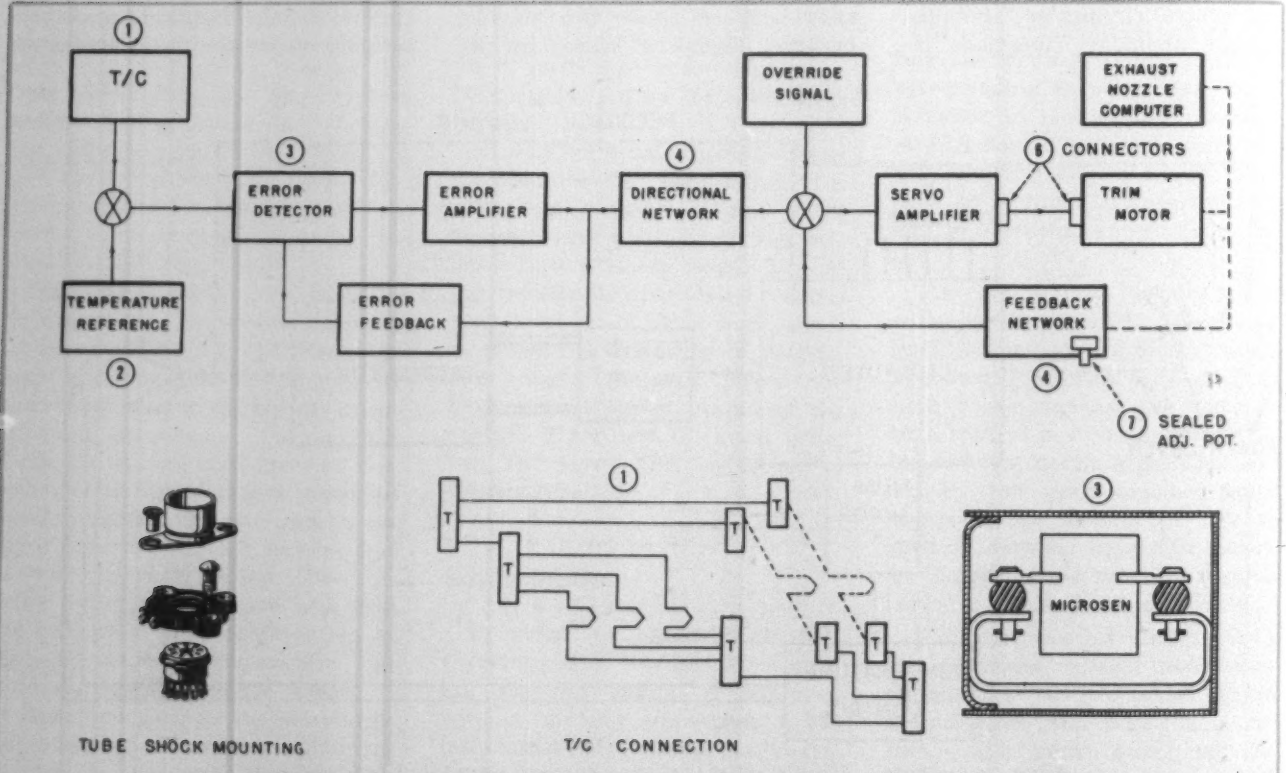


Fig. 2—Block diagram of temperature control. Sketch in the lower left corner illustrates a method used to isolate sensitive electronic components from the chassis on which they are mounted

ing board—the chassis on which they are mounted.

These design features have been developed over a considerable period of time. Although they add materially to the reliability of the temperature control, they are not in themselves sufficient. It is only by careful, thorough engineering and the best possible co-operation by engineering, manufacturing, quality control, and field service that a really excellent temperature control can be produced. There is no royal road to building safe temperature controls.

From a paper entitled, "Reliability of Temperature Controls" presented at the Aeronautic Meeting of SAE in Los Angeles, Oct. 1954.

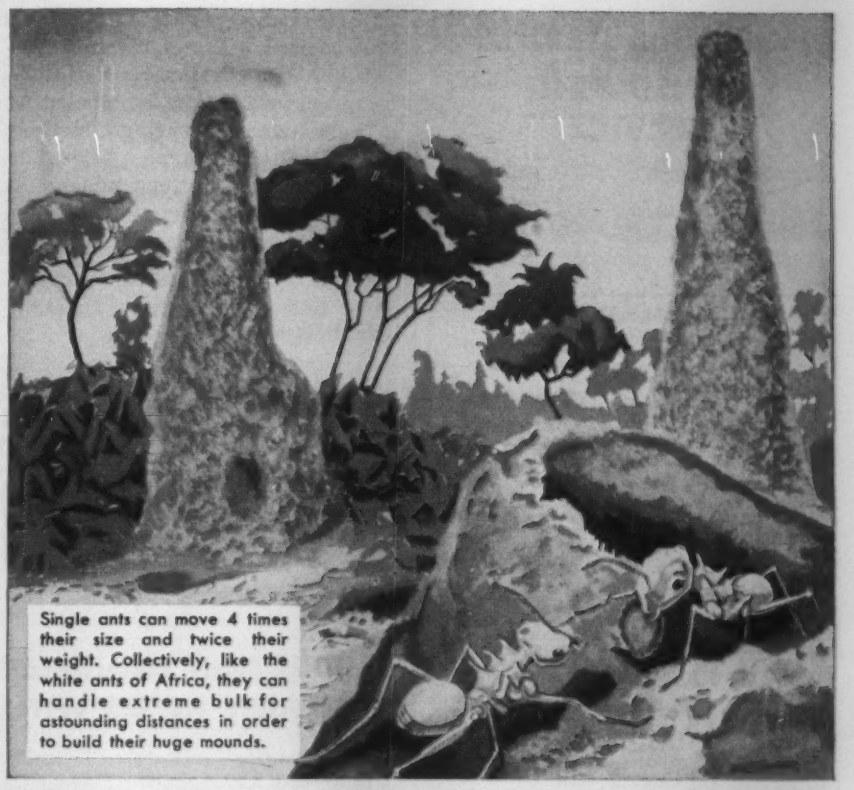
AUTOMATION TODAY AND TOMORROW

D. S. HARDER
Ford Motor Co.
Detroit, Mich.

AUTOMATION, as you know, has become a phrase used to describe almost everything that is automatic. During the early development period of automation at Ford, we derived our own working definition. We had to do this to be able to talk with engineers, machine tool builders, and others about the objectives of our program.

Initially, we stated, "Automation is the automatic handling of parts between progressive production processes." This sounds so clear and concise. We soon found out that this was not the case. The complex problems hidden behind these simple words were of major proportion. While our early definition is still substantially correct, I feel that it should be broadened considerably.

Mr. E. W. Brainard of the Hughes Aircraft Co. defines automation as follows: "Automation is more than merely transferring. Nor is it a pushbutton factory. It is a philosophy that may extend back to the design of the product. It is a new method of manufacture, not necessarily a new way of cutting metal, but a way of controlling the various processes. Automation is a philosophy of design,



Single ants can move 4 times their size and twice their weight. Collectively, like the white ants of Africa, they can handle extreme bulk for astounding distances in order to build their huge mounds.

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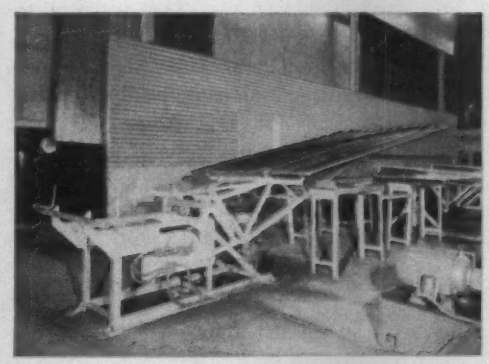

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it is a manufacturing method, and it is control within a machine."

I like this particular definition because automation is labeled as a new manufacturing method. This, I believe, is true. There are many other definitions equally as acceptable, but anyone who fails to recognize this fact has missed the point.

Prophets of Doom

I am deeply disturbed when I hear the short-sighted groups running down and damning this new manufacturing innovation. The same type of people has ridiculed every significant improvement in production processes since the start of the industrial revolution. They just don't know what they are talking about.

I, for one, want to think of automation as a new concept—a new philosophy—of manufacturing. If you will begin thinking in these terms, others will soon understand the true meaning. Its future value to our economic system is based on our ability to understand the potentials and harness them for industrial use.

From a talk entitled, "Automation—Key to the Future" presented at the Quad-City Conference on Automation in Davenport, Iowa, Aug. 1954.

PRODUCTION ENGINEERING COMPARES NOTES WITH OPERATIONS RESEARCH

By A. SCHULTZ, Jr.
Cornell University
Ithaca, N. Y.

AN IDEAL WAY to point out the differences between production engineering and operations research would be to show how the same problem was attacked by two groups equally competent in their own areas. Such a presentation would be most interesting and perhaps a relief from the numerous so-called industrial case studies which tell of the tremendous savings an operations research group achieved after the failure of efficiency engineers or conventional industrial engineering.

Unfortunately, such an example is not available and it seems certain will not be. The few industrial applications of operations research in the production-engineering area which repeatedly crop up in papers on the subject do not meet our purpose either. They are difficult to view in a detached manner removed from the proprietary interest of those who originated the solution or sponsored the originators. They appear at best to represent minor advances as far as novelty of results or overall economy when compared to competent practice. This does not imply criticism of the method and is perhaps an inevitable result of early application of a new idea.

Yet a brief comparison of methods in an example, although a hypothetical one, seems worth while. Let us assume the problem is the layout of a plant to produce a line or products. The production-engineering steps include product analysis for manufacture; determination of the sequence and detailed processing steps by which the product is to be made; development of any new processes and methods required; estimation of time and quantity factors; selection of equipment and design of manufacturing layout, tooling, gaging and inspection methods; handling and flow procedures; cost estimation and many other steps depending on industry, firm, and product.

Generally these will be completed to the best ability of the individual engineers and the group. Specialists in various aspects of manufacturing such as tool design, handling, work measurement, processing, layout, etc., will be involved and the co-operative effort will be evaluated in terms of cost of manufacture in labor, material, and some measure of investment and overhead. If the investment is too high or cost is too great based on previous experience or knowledge of competition, more effort may be

devoted to the problem. Otherwise the fact that a way to manufacture the product line successfully has been designed is sufficient.

Without implying that operations research can substitute for technical and design competence, one can state that some of the steps in the process would be approached quite differently were the opportunity offered. One is the original definition of the problem in which such factors as volume are considered. Here rather searching inquiry is called for as to variation, accuracy, significance and trends of volume and mix data.

That this involves organizational entities and concepts outside of normal production-engineering responsibility is evident. The results are important to ensure a design most susceptible to the type of control needed as well as in the method of testing the completed design to evaluate optimal performance. The data and estimated times for determination of machine grouping and line balancing would be handled differently and methods of computation which recognize inherent variation would be utilized.

Before completing the layout, in all likelihood the operations-research group would attempt to determine if optimal results are obtained. This would involve development of measures quantitatively related to design parameters to indicate possible accomplishment. In addition some sort of testing or "gaming" would be resorted to in order to determine the response of the layout to various conditions of volume and product mix. This would include both those which are likely and the unlikely extremes, thus obtaining some impression of critical limits and parameters.

To some extent individual engineers are working along these lines here and there in production engineering, but this is not general. This type of approach leads to utilization of specialized techniques, not frequently practiced in engineering, and involves a sincere, unbiased, objective adherence to the ideal of comprehension of the operation and its causes rather than the more temporal objective of getting a job done. This sketchy illustration leaves much to be desired but is perhaps sufficient to point up the contrast.

Future Expectations

From the foregoing discussion and the many papers available on the subject a number of conclusions can be drawn, and in turn these conclusions raise serious questions. The first conclusion is that a considerable number of mathematical developments and derived techniques have come about during the past decade, many under security limitations, which evidently have not been assimilated by practicing engineers who might find them useful.

Questions which might follow have to do with the potential value of these techniques and the method of transmission to those who might benefit by them. Obviously these techniques were not available when many of the currently employed methods of industrial and production engineering were developed. Therefore it is to be ex-

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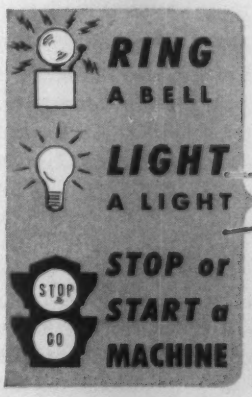

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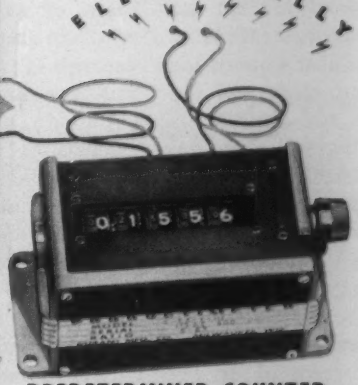

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pected that those who attack the same problems with the incremental advantage of more powerful methods will develop different and probably improved techniques of solution.

Techniques referred to are being used in military operations research and presumably are being developed further. A problem exists in the transferral of any new development to practice, and when a development which takes place under the sponsorship of one discipline, such as statistical mathematics, is of use to a different one in specialized applications, such as production engineering, this problem is intensified. Assuming that the developments of interest to us are refined and applied under the guise of classified military or commercial operations research by groups of individuals of varying backgrounds and training, the engineer has cause to be concerned about the dissemination of such knowledge.

A second conclusion that can be drawn is that to date the value of industrial operations research performed as described by nonengineers in the areas of direct concern to the production engineer has not been clearly established. This raises questions as to methods of evaluation and bases of comparison. It is a fact that much military operations research is taking place and most military staffs in the United States, Canada, and England now have operations research groups. Their work is largely classified and is presumably worth while, yet the environment is so different from that of industry that it is dangerous to jump to the conclusion that operations research in industry will be equally successful or necessarily economical.

Study of the cases of industrial operations research available discloses in most early articles considerable ignorance of industry and production engineering on the part of the authors and few examples of other than common engineering practice. More recently evidence of an approach and methodology apparently very worth while has appeared and we can profit thereby. Yet others seem to be retracing the ground covered by the production engineer some 15 to 20 years ago. The important fact is, that in no case is there available a proper evaluation of the overall economic problem, and as mentioned earlier, this may be impossible.

Often it is not recognized that any process or operation which is allowed to progress for some time without review inevitably is affected by creeping obsolescence and change. Almost any conscientious study will result in material improvement. The standard of comparison, however, is the original state prior to the study and for our purpose this is inadequate. From any evidence to date or data publicly available it cannot be concluded that in any case operations research has returned more per dollar spent than an equal or lesser expenditure by competent production engineers. This does not infer that it is not possible to demonstrate the value but merely that it has not been done in a satisfactory fashion in the area of production engineering. Some firms are now experimenting and it is to be hoped that sufficient data for a judgment ultimately will be available.

A third conclusion is that the methods and objectives of operations research as described herein differ quite markedly from the traditional ones of the production engineer. If we grant that the methodology and techniques are applicable although of uncertain economy, we are led to question the proper place of operations research in the area of production engineering. That there are many problems crying for better methods of solution cannot be denied. Examples are materials handling, line balance, machine utilization, and many others. Methods to solve these can be used repeatedly. Also, many of the economic policies, constants, or assumptions which restrict the engineer need further study.

If all of these problems have anything in common it is the extent to which they involve analytical study of data originating in different organizational divisions of the firm. This implies extensive information gathering and wholehearted co-operation in the whole process of analysis, interpretation, and experimentation or test. The statement has been made repeatedly that the place for operations research is at a high level on the organization chart. At the other extreme the statement is made that any engineer can do this research as part of his function. Both have a familiar ring and any firm interested would do well to study the history of statistical quality control which furnishes many parallels including these.

Middle Road

Certainly experience would indicate a number of considerations. First, no one answer suits all situations. Secondly, adequate analysis and thoughtful research do not take place as a part-time job subordinated to daily pressures, and hence a unit with this sole function is necessary. Thirdly, any values to be derived will come solely through adoption of new methods across channels. This difficult problem of selling the solution or the desire for one demands special competence and organizational ability and is perhaps the most important single factor. Finally, the engineer and the scientist both have a place in the program.

Research on a scope sufficient to benefit the production engineer will demand much closer contact and familiarity with the present state of the art than is evidenced by performance of the type of operations research groups that are made up of pure scientists operating from on high. It also will demand methodology and techniques not possessed by the average engineer. A middle path seems quite essential with a real interchange of ideas, skills, and techniques that does not come about overnight. It does not appear likely that a firm will be able to buy a package of operations research for work in the area of production engineering but must to a considerable degree develop an integral function.

From a paper entitled "Operations Research Related to Production Engineering" presented at the Annual Meeting of ASME in New York, Nov.-Dec. 1954.

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Cold Drawing
Thread and Form Rolling
Metal Spraying
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Die Casting
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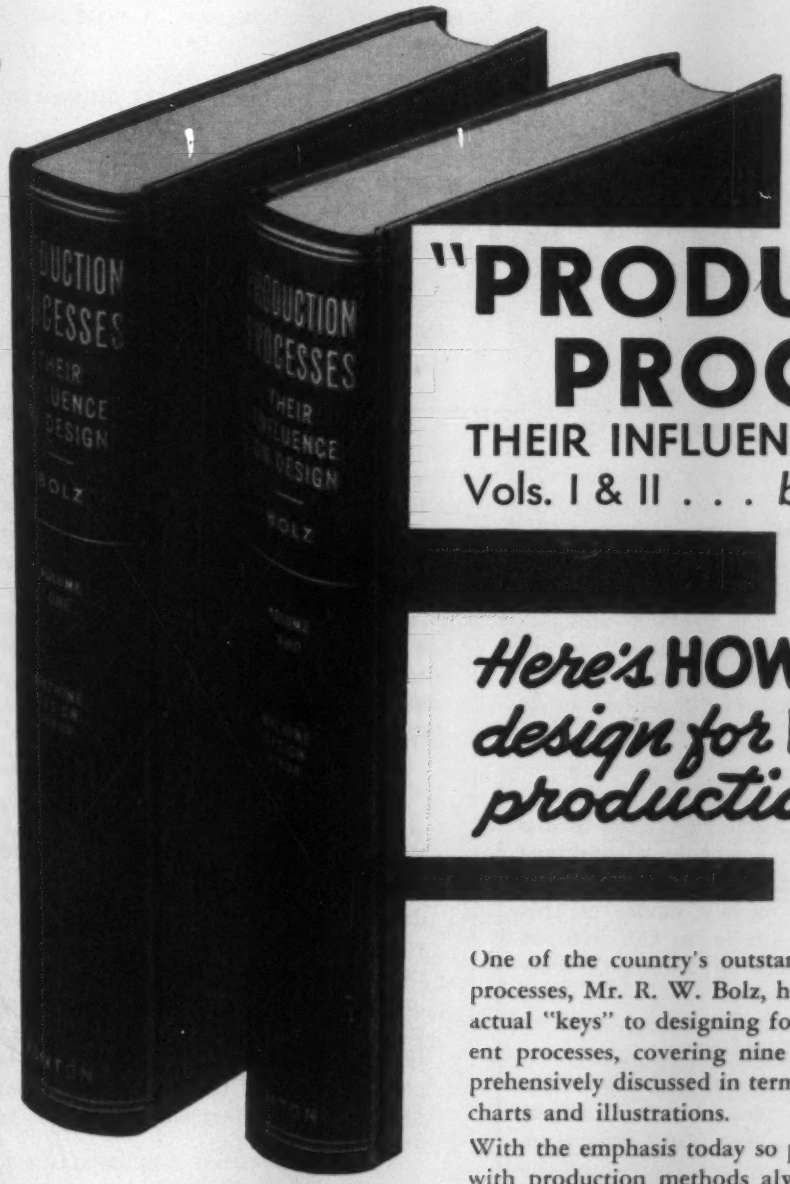

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AUTOMATION

PATENTS

Copies of patents are available at 25 cents each from the Commissioner of Patents, Washington 25, D. C.

Controls

REMOTE CONTROLLED SWITCH

Self-starting synchronous motor drives rotary cam actuator for switch through normally open magnetic clutch and reduction gearing unit arranged in a circuit to selectively respond to energizations lasting for different periods of time. Patent 2,675,442 by Anthony Van Ryan, assigned to McGraw Electric Co.

RECORDING MECHANISM

Support member has four cable guides and means to effect relative linear movement to a carrriage mounted thereon, which carriage in turn has four cable guides and means to move a device on this carriage linearly at right angles to the path of the carriage. Patent 2,675,291 by Donald C. Webster, assigned to Librascope Inc.

FUEL CONTROL FOR TURBOJET ENGINES

Apparatus is associated with a fuel line and a compressor, comprises a source of fuel at superatmospheric pressure and a regulating means, including a fluid motor with variable area restriction passages whereby the flow of fuel is a function of air pressure differential, one component of which is a pressure in the engine. Patent 2,697,-909 by Milton E. Chandler, assigned to Niles-Bement-Pond Co.

♦ ♦ ♦

Data Processing

MAGNETIC MEMORY CHANNEL RECIRCULATING SYSTEM

A device for converting alternately directed magnetic flux alignments on a moving magnetic memory channel into an equivalent electrical signal having corresponding alternate first and second voltage levels; electrical signal being in synchronous relationship with a timing signal which includes a series of consecutive spaced low voltage levels. Patent 2,698,427 by Floyd G. Steele, assigned to Digital Control Systems Inc.

INFORMATION RECORDING AND REPRODUCING SYSTEM

Means for generating a cyclic reference signal; a cascade of multiphase synchros each having at least two field windings and a rotor winding; phase splitting means connected to the generative means and the field windings to produce cyclical electrical signals of different phases and of the same frequency as the reference signal, whereby a cyclical information signal is induced in the rotor. Patent 2,698,410 by Royal Glen Madsen, Michael E. Stickney and Roland C. Hawes, assigned to Beckman Instruments Inc.

♦ ♦ ♦

Handling

NONPULSATING AND VIBRATIONLESS CONVEYOR

Laterally spaced drive sprockets each with drive chain, the pitch of which is a fractional value of the pitch of the slats that extend between these chains; slats are connected to chain in such a manner as to accommodate a variation in the effective pitch length of the slat and compensate for the chording effect encountered in passing around the sprockets. Patent 2,698,078 by Homer S. Harrison, assigned to Allied Steel and Conveyors Inc.

SUSPENSION TROUGHING IDLER

Spaced idler rollers are releasably clamped to flexible element suspended between inwardly tilted bearings supported by brackets; conveyor belt of width narrower than roller span rests on rollers in trough section position. Patent 2,698,077 by George Baechli, assigned to Joy Mfg. Co.

♦ ♦ ♦

Machines

PISTON RING MAKING MACHINE AND PROCESS

Stamped channel shaped ribbon of metal has web and parallel spaced slit crowns and is continuously advanced through operations that rough work the slit crowns while cold, heat the material and hot work the slit crowns, liquid quench to harden, coil the advancing hot worked metal, heat and slowly cool the metal to draw and set it, stretch to separate crowns, grind the edge of the crowns of the advancing coil to cylinder bore size, allow material to contract, again stretch the coiled metal and successively sever the leading coils in the form of piston rings. Patent 2,697,865

by Samuel H. Norton, assigned to Thompson Products Inc.

MACHINE FOR MAKING SETUP BOXES

Assembles setup boxes having a front, bottom, back, body ends and body tabs; a lid, a lid flap, lid ends and lid tabs. Machine has vertically moving forming plunger about which the box is formed by folders timed to move toward the plunger as it is moving downwardly. Patent 2,697,968 by Omer E. Cote and George H. Nilsen, assigned to United States Automatic Box Machinery Co.

COIL WINDING MACHINE

Two stepped coil forms rotatable in tandem relation; reciprocable means for guiding wire onto the steps of the coil form in layers; means for counting number of turns of wire wound on each step and predeterminately energizing a device that moves the form in steps to successively wind the first coil; reset and re-energizing of counting and winding mechanisms to make another stepped coil on the second form and automatically render the coil forms readily removable. Patent 2,698,033 by Bernard W. Ammann and Raymond A. Young, assigned to Emerson Electric Mfg. Co.

APPARATUS FOR PRODUCING PLASTERBOARDS HAVING PRINTED EDGE INDICIA

Printing press for continuously printing indicia upon a taut moving web has co-operating type and platen rolls between which said web passes. These rolls are driven only by the frictional contact between the moving web and drive rolls to which they are connected. Patent 2,697,982 by Clarence A. Carlson, assigned to United States Gypsum Co.

♦ ♦ ♦

Measuring

INDICATING, SIGNALING, AND RECORDING DEVICE

Apparatus for gaging a portion of a test part wherein a probe means is brought into engagement with the part and in the course of making this contact provides an electrical signal which in co-operation with an indicating means affords an indication of the dimensional condition of that portion of the part. Patent 2,697,879 by William S. Tandler, David S. Walker, and Morris Grossman, assigned to Warner and Swasey Research Corp.

METHOD AND APPARATUS FOR MEASURING THE MASS PER UNIT AREA OF SHEET MATERIAL

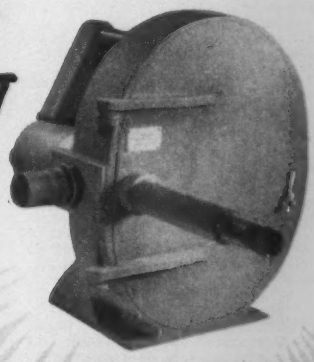
Radiation detecting device in the form of an ionization chamber comprising an inner and outer electrode in an annular spaced-apart relation; outer electrode is a tube with openings at right angles to its axis which define an aperture, the effective angle of acceptance of which is less than 180 degrees but greater than the angle of emission from the source which is spaced apart in predetermined relation to the detector. Patent 2,675,483 by Geoffrey J. Leighton, Ronald F. Maskell, and Norman Z Alcock, assigned to Isotope Products Ltd.

FOR THE FIRST TIME IN ONE CAMERA

TOP PICTURE QUALITY

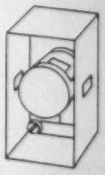
COMBINED WITH

GREATEST SPEED RANGE



FASTAX HIGH-SPEED MOTION PICTURE CAMERAS

IMPROVED ROTATING PRISM



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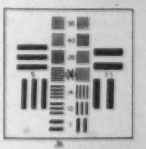

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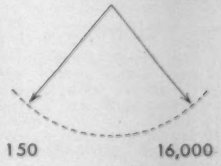
GREATEST SPEED RANGES



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CUMULATIVE EDITORIAL INDEX

Including six issues. Number preceding the hyphen is month of issue; those following are page numbers in that issue.

A

Abbe, E. H.
Heavy Material Handling, 2-26
Absorption, radiation, 9-47
Accounting, 12-31
Air cooling system, 1-30
Air gaging, 11-21
cartridges, 1-102
Air sampling, 1-111
Aircraft engines, 9-113
Amplifier,
diode, 1-45
magnetic, 9-105; 11-112, 116
servomotor, 9-49
Analog computer, 9-68; 10-96
heat transfer, 9-34
Analog to digital conversion, 10-41; 12-98
Analog vs digital computer, 9-63
Analysis,
dielectric, 12-108
mathematical, 11-110
process stream, 11-46
Analyzer,
infrared, 9-47
yarn, 9-70
Arbors, loading, 1-18
Armature manufacture, 10-21, 105
Assembly, 9-22, 109; 10-23, 53; 11-12; 2-33
Atomic energy, 9-69
Atomic Energy Commission, 9-107
Atwood, S. G.
Layout for Handling, 10-46
Automatic control, 10-108
basic characteristics, 9-65
terminology, 9-65; 10-51; 11-59; 12-63; 1-49
Automatic elevator, 9-68; 10-104
Automatic machines, 9-109; 1-16
Automatic systems, 11-47
Automation,
application of, 9-21; 2-8
concepts, 10-100; 1-10
definition of, 10-18
development of, 9-20
history, 10-102
in the office, 10-50; 12-31; 1-39
job shop, 10-46
philosophy, 2-117
planning for, 9-22; 10-18, 47
product design, 9-23, 51; 11-18
steel industry, 11-107
Automobile manufacture, 2-8
Auxiliary operation, 11-30
loading arbor, 1-18

B

Balancing, 10-38
Behrend, R. H.
Assembling Low-Budget Jobs, 10-53
Berg, R. H.
Continuous Weighing of Solids, 11-39
Bin, weighing, 11-39
Binary number system, 10-42
Bishop, L. J.
Latex to Foam Rubber, Automatically, 11-31
Blast furnace, charging control, 2-29
Bois, R. W.
The New Automation, 9-14
Design for Manufacture, 11-18
Real Advance, edit., 2-25
Bonding, induction heat, 9-72
Bottle sealing, 11-23
Bowling, 12-107
Box making, 2-123
Broaching, 11-14
Business machines, 12-31; 1-39; 2-69

C

Camera, 11-14
oscilloscope, 1-12
Candle dipping, automatic, 1-22
Capacitance, 9-65
Capacitors, electronic, 10-109; 2-127
Capacity, 9-65
Cards, punched, 10-9; 12-106; 2-65
Cartridges, air gaging, 1-102
Casting, 10-19
Cement product mixing, 2-59
Circuits,
control, 11-116
etched, 10-11
printed, 2-14
servoamplifier, 11-64
switching, 9-113
television, 2-31
Cleaner, ultrasonic, 9-72; 12-102
Clock, setting mechanism, 9-110
Closed-loop,
concept, 10-57
systems, 11-111
Clutch, electromagnetic, 9-71
Coal,
handling, 2-26
mining, 2-46
plant lubrication, 1-52
Coffee bean sorting, 2-74
Coin,
collecting device, 9-109
controlled timer, 9-109
operated device, 9-109
weighing device, 10-38
Color sorting, 1-10; 2-74
Common language tapes, 12-31; 1-39
Commutators, 9-109
Components, feedback systems, 9-60
Compounding, rubber, 9-50
Computers, 9-108; 12-109; 1-12; 2-10
analog, 9-34; 10-96
component, 1-45
control, 1-9
digital, 10-108; 11-9; 12-14; 1-16; 2-12
elements, 10-97
feedback systems, 9-62
mechanical, 10-96
Condenser manufacture, 10-20
Console control, 12-42
Contacts, electrical, 10-13
Container, decorating, 9-37
Contents, 2-3
Continuous gaging, 12-57
Continuous production, acetylene, 9-64
Control,
air pollution, 1-10
aircraft, 9-113; 2-114
centerless grinding, 12-61
circuits, 1-62
closed-loop, 9-58; 10-96, 101
electric arc furnace, 12-96
electrical, 10-104; 11-116; 12-66, 106; 1-22, 110; 2-28, 122
electronics, 10-28, 34, 39, 44; 12-8, 53; 1-9; 2-12
engine fuel, 2-122
feedback, 9-57
film, 9-66
frequency, 12-106
gage, 1-55
hydraulic, 10-104; 1-62
ingot soaking pits, 2-10
instrument, 9-108; 12-106
machine, 10-98; 2-10
motor, 2-126
nozzle, 2-114
open-loop, 9-58; 10-96
panel, 12-42
parallel disk grinding, 12-62
photoelectric, 9-69; 10-35; 11-36
pneumatic, 10-34; 11-116; 12-53
press unloader, 12-21
refinery, 12-53
tape, 10-28; 12-9
temperature, 10-104; 2-114
tension, 9-106
terminology, 9-59, 65; 10-51; 11-59; 12-63; 1-49; 2-61
tool, 9-44
weight, 1-13
Controllers,
action, 12-63; 1-49
adjustments, 1-49
Converters,
analog to digital, 10-41; 12-98
card to tape, 12-37
tape to card, 12-37
Conveying, 10-47; 12-106
Conveyors, 9-67, 70; 10-35, 105; 11-34; 2-14, 126
belt, 9-109; 2-26, 46, 122
chain, 9-109
coal, 2-26
feeding, 12-41
idler, 2-122
ore, 2-26
overhead screw, 2-73
rubber, 1-9
slat, 2-122
weighing, 11-39
Cooling system, air, 1-30
Counter, 12-107
Crusher, continuous process, 9-64

D

Data processing, 9-70, 108; 10-9, 12, 41; 11-9, 22; 12-31, 98, 106, 109; 1-12, 15, 16, 17, 39; 2-65, 122
Dead time, 9-65
Design, 11-116
Digital computers, 10-108; 11-9; 12-14; 1-16; 2-12
Digital vs analog computer, 9-63
Diode amplifier, 1-45
Distribution: See warehousing
Drive and control system, 1-31
Drive, electronic variable speed, 10-44

E

Economics, 9-15, 22, 28, 113; 10-27; 1-33
Education automation, 9-70
Egg,
cleaning, 9-109
handling & sorting, 12-27
Electrets, 10-109
Electrical,
arc furnace control, 12-96
control, 10-104; 11-116; 12-66, 106; 1-22, 110; 2-122
power, 10-17
timer, 1-70
transmission, 10-103
weighing, 11-40
Electronics, 1-12
capacitors, 10-109
control, 10-34, 39, 44; 12-8, 53; 1-9; 2-12
diodes, 1-45
modular design, 11-19
servo, 11-61
tube, 10-8
Electroplating machine, 11-12
Electrostriction, 9-68
Elevator, 9-68; 10-104
Engine, aircraft, 2-122
Engineering,
analysis, 9-112
organization, 2-35
systems, 11-47; 2-35
Equipment, data processing, 12-32
Experimental method, 10-108

F

Feedback, 10-57, 98; 11-49; 12-66
control, 9-57
speed control, 9-61
Feeders, 9-23; 10-52, 104; 11-116
Filing, punched tape, 2-72
Film control, 9-66
Finishing, steel, 11-108
Flowmetering of solids, 11-39
Foam rubber, 11-31
Forms, paperwork, 2-67
Foundry automation, 9-100
Frequency control, 12-106
Furnace, open hearth, 11-108

G

Gaging, 1-111; 2-123
air, 11-21; 1-102
continuous, 12-57
cyclic processing, 1-55
for process control, 2-42
gear, 9-46; 1-16
pushrods, 2-42
radiation, 9-107; 11-108; 2-123
radioisotope, 9-67
weighing, 9-27; 1-111
wire, 12-59
wrist pins, 2-42
Garrott, P. B.
Automation in Paperwork, 12-31; 1-39; 2-65
Gear shaving and gaging, 9-46; 1-16
Gittens, E. D.
Management of Systems Engineering, 2-35
Graphic panel, 9-18
Grinding, 12-61; 1-55; 2-62
Gyro, 2-16

H

Hadekel, R.
Hydraulic and Pneumatic Servos, 10-57; 11-49; 12-43; 1-61; 2-48
Hagerman, L.
Attachment Automates Container Decorating, 9-37
Handling,
coal, 2-26
conveying, 9-108, 109; 10-35, 47, 105; 12-27, 41, 97, 106; 1-9, 28, 57; 2-26, 46, 73, 122
data, 10-9; 12-31; 1-39; 2-65
egg, 12-27
feeding, 9-20, 108; 10-52, 104; 11-116; 1-50; 2-62
ore, 2-26
orienting, 10-35, 104; 11-20
parts, 11-58
radioactive, 9-41
sand, 1-16
sorting, 10-38, 104; 12-28, 107; 1-110; 2-74
unloading, 12-19; 1-50
Hardness testing, 11-10; 2-44
Hauk, E.
Attachment Automates Container Decorating, 9-37
History, automation, 10-102
Holtje, M. C.
Feedback System Regulates Voltage, 12-66
Hopper, weighing, 11-39
Howard, S. R.
Weight Controlled Volume Filling, 9-24
Humidification systems, 2-20
Hunting, 10-100
Hydraulics, 9-41
control, 10-104; 1-37
elements, 9-42
equipment, 1-31
presses, 10-53
servos, 10-57; 11-49; 12-43; 1-61, 2-8, 49
systems, 9-45; 1-22; 2-115
weighing, 11-40

I

Index, turret, 9-39
Indexing, 9-108; 10-53; 11-62, 116
Induction heating, 11-104
Inspection, 9-21; 10-28, 38
automatic, 12-57
Instrumentation, 9-113
Instruments, 9-17
control, 12-106
recording, 9-108; 1-110; 2-122
Integrated data processing, 12-31; 1-39; 2-65
Interchangeable manufacture, 11-18

J

Jaws, press unloader, 12-23
Job Shop Automation, 10-46
Johnson, E. S.
Machine Mobility, 9-29
Johnson, R. N.
Electrical Maintenance in Automation, 9-40

K

Kendall, J.
Remote Handling with Hydraulics, 9-41
Knapp, H. M.
Design for Automatic Production, 9-51

Kraus, C. E.
Management's Stake in Automated Handling, 9-20

L

Labor, 9-13, 14; 1-25
Lemon sorting, 2-74
Lift truck, 11-58
Light, 10-17
Limit switch, 9-108
Lindholm, P.
Feedback Control Systems, 9-57
Loading arbors, 1-18
Lubrication systems, 1-52

M

Machine control, 10-98
Machine mobility, 9-29
Machine tools,
boring and facing, 10-10; 1-38
broaching, 11-14
fixture, 10-12
grinding, 12-61; 1-55; 2-18, 62
hydraulic press, 10-53
milling, 9-109; 10-26; 12-107
power brushes, 10-12
screw slotter, 10-44
transfer, 9-101
turret lathe, 1-50
Machines,
assembly, 10-23
automatic, 9-109; 1-16
bottle decorating, 9-38
box making, 2-123
business, 12-31; 1-39; 2-65
candle dipping, 1-22
cigarette making, 9-67; 2-20
coil winding, 2-123
condenser winding, 10-20
electroplating, 11-12
extrusion, 10-105
milling, 9-69, 109; 10-26
molding, 9-109; 10-105
mounting of, 9-33
paper coating, 1-34
repair of, 9-29
spline rolling, 12-41
unloading, 12-19
vacuum metallizing, 1-70
welding, 10-26
Magnetic amplifier, 9-104; 11-112
Maintenance, 9-29
electrical, 9-40
plant, 1-105
Management, 9-13, 16, 20
office, 12-31; 1-39; 2-35
Manual control, 10-108
Manufacture of,
armatures, 10-21, 105
automotive condensers, 10-20
automotive parts, 12-22; 2-62, 122
boxes, 2-123
commutators, 9-109
crankshafts, 2-62
cylinder heads, 1-38
dipped candles, 1-22
electronic tubes, 10-8
lamps, 9-108
petroleum products, 12-53
pipe, 12-106
piston rings, 2-122
rubber parts, 11-31
screwdrivers, 12-107
screws, 10-44
sheave and bracket, 10-53
splined shafts, 12-41
stamped parts, 12-19
starter brush end plate, 10-52
telephone relay, 9-51
television circuits, 2-31
television tubes, 1-70
Marvin, P. R.
Engineering Automatic Systems, 11-47
Mass production, 11-18
Materials, dielectric, 11-116
Measuring,
automatic, 12-57
flatness, 9-109
gaging, 11-21; 1-111; 2-123
instrument, 11-10
pressure, 1-10
temperature, 10-104; 12-9; 1-11
weighing, 1-111; 2-59
Mechanical, weighing, 11-40
Memory,
device, 12-28, 42; 2-122
disk, 11-45
Merchandising, 9-109
Milling machine, 9-69, 109; 10-26
Mining, coal, 2-46
Mixing, cement product, 2-59
Mobile color sorting, 1-12
Mobility of machines, 9-29
Modular design of electronics, 11-19
Molding,
machine, 9-109; 10-22, 105
rubber, 11-31
Moore, B. P.
Remote Handling with Hydraulics, 9-41
Mounting of machines, 9-33

N

Nucleonics, uses for, 9-106
Numbering code systems, binary, 10-42

O

Office Automation, 10-50; 12-31; 1-39
Oil refining, 9-17; 12-53
Operations research, 2-118
Ore, handling, 2-26
Organization, engineering, 2-35
Orienting, 10-35, 104; 11-20
Oscilloscope camera, 1-12

P

Packaging, 9-22, 110; 10-26, 32, 35; 1-111
bottle sealing, 11-23
egg, 12-27
granulated material, 9-24
Paint spraying, 11-44; 12-9, 107
Pallet loading, 10-35
Panel, graphic, 12-54
Papermaking, 12-8
Paperwork, mechanized, 12-31; 1-39; 2-65
forms, 2-67
Peeps, D. J.
Pneumatic Control for Paint Spraying, 11-44
Photoelectric,
control, 9-69; 10-35; 11-36
sorting, 2-74
Photography, 11-12
developing, 9-108
Phototheodolite, 1-17
Piston ring, manufacture, 2-122
Planning, 9-22; 10-18, 47
Plant layout, 9-29, 103; 10-46
Plating, tin, 11-109
Pneumatic,
controls, 10-34; 11-44, 116; 12-53
servos, 10-57; 11-49; 12-43; 1-61; 2-49
timers, 11-28
weighing, 9-24; 11-40
Positioning, 11-61
Potentiometers, 10-109
Power, electrical, 10-17
Presses,
conveyor type, 10-9
handling to, 10-49, 52
hydraulic, 10-53
unloading, 12-19
Pressure measurement, 1-10
Printed circuits, 1-10; 2-14, 31
Printing, 9-108; 10-26; 11-22; 12-9; 2-123
bottle, 9-37
cloth, 11-28
Process control, 12-53
Processing, continuous, 9-47, 64; 1-34
Product design, 9-23, 51; 11-18; 2-31
Production engineering, 2-118
Programs, 11-47
Project tinkertoy, 11-19
Proportioning,
batch process, 9-50; 2-59
ultrasonic, 10-10
Pumps,
controlled servos, 1-67; 2-49
variable delivery, 1-61
Punch press, 11-61
Punched cards, 10-9; 12-37, 106; 2-65
Punched tape, 10-28; 12-31; 1-39; 2-65
filing, 2-72
Pushrods, gaging, 1-111

R

Radiation,
analysis, 9-48
gaging, 2-123
Radioisotope gage, 9-67
Rainey, W.
Electronic Servo Positioning, 11-61
Recording,
camera, 11-14
data, 10-28; 12-12
instrument, 9-108; 1-110; 2-122
tape, 11-12
weight, 9-27; 11-12
Rectifiers, 2-14
Refining, 9-17; 12-53
Regulating systems, 11-110
voltage, 12-66
Relay,
ceramic, 9-68
telephone, 9-51
Repair, machine, 9-29
Resistance, 9-65
Robots, 11-17
Rolling, steel, 11-108
Ross, N. S.
Weight Controlled Volume Filling, 9-24

S

Sampling, air, 1-111
Sanford, A. C.
Automatic Gaging, 12-57; 1-55; 2-42
Savet, P. H.
Computers Can Be Simple, 9-34
Schroeder, C. J.
Automatic Machines Make Hand-Dipped Candles, 1-22
Screws,
conveyors, 2-73
slotting of, 10-44
Sealing bottles, 11-23
Sehn, F. J.
New Vistas in Stamping, 12-19
Semiconductors, 1-45
Servo,
positioning, 11-61
pump controlled, 1-67
systems, 1-61
Servoamplifier, 11-64
Servomechanisms, 11-116; 12-43
electrical, 10-104
hydraulic, 10-57; 11-49; 12-43; 2-8
pneumatic, 10-57; 11-49; 12-43
Servomotor, 12-66
Servosystems, hydraulic, 2-115
Shaft, armature manufacture, 10-22
Shaving, gear, 9-46
Shell molding, 9-99
Slide valves, 2-49
Slotter, 10-44
Soaking pits, ingot, 2-10
Solids,
continuous weighing, 11-39
flow metering, 11-39
Sorting, 10-38, 104; 12-107; 1-110; 2-42
coffee beans, 2-74
color, 1-10; 2-74
egg, 12-27
lemon, 2-74
photoelectric, 2-74
Spectra, infrared, 9-47
Spectrograph, x-ray, 2-18
Spectrometer, mass, 11-46; 12-11
Spectrometry, 9-67
Speed regulation, 11-112
Spraying, 11-44; 12-107
Stampings, 11-8; 12-19
Standards, 9-65; 10-51; 11-59; 12-63; 1-49; 2-61
Steering control, 10-104
Stern, R. K.
Electromechanical Coder, 10-41
Switch, limit, 9-108
Systems, 11-14
engineering, 11-47; 2-35
humidification, 2-20
weight control, 1-13

T

Tapes,
common language, 12-31; 1-39; 2-65
control, 10-28; 12-9
data processing, 12-31; 1-39
punched, 10-28; 12-31; 2-65
recording, 11-12; 2-10
Telemetering, 11-10; 12-106
Telephone, answering, 9-108
Television, 11-108; 1-70; 2-31
Temperature measurements, 9-122, 139; 10-104; 12-9; 1-10
regulator, 1-14
Terminology,
basic characteristics, 9-65
characteristics of automatic control, 11-59
control system, 9-59
controller action, 12-63; 1-49
controller elements and characteristics, 2-61
processes, 10-51
Testing,
air sampling, 1-111
hardness, 11-10
nondestructive, 10-28
ultrasonic, 10-28
Textile machines, 11-28
Tice, C.
Pushbutton Manufacturing, 10-18
Timers, 9-110; 11-28; 1-70
Tinkertoy project, 11-19
Tooling, 9-71; 1-38
Transducer,
heat transfer, 9-35
self heating, 9-36
Transfer machines, 9-101; 2-62
Transient analysis, 9-112
Transistors, 9-113; 10-109; 11-9; 12-109; 1-12, 46
Transmission,
data, 10-9
electrical, 10-103
Trucks, lift, 11-58
Tying, 10-32

U

Ultrasonic,
cleaner, 9-72
industrial cleaning, 12-102
properties of liquid, 11-116
proportioning, 10-10
testing, 10-28
Unloading, press, 12-19

V

Valves, slide, 2-49
Variable delivery pumps, 1-61
Vehicles, control, 9-108; 10-104
Ventilation, 11-116
Voltage regulator, 12-66

W

Warehousing, 9-70, 110; 10-35
Weighing, 9-24; 11-12
automatic, 9-50; 11-32, 37
continuous, 9-67; 10-38; 11-39
Weight measurement, 10-102; 1-13, 111
Welding, machine, 10-26
Winding machine, 10-20
Wire-tieing, 10-32
Wrapping, 9-110

X

X-ray, spectrograph, 2-18

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MAGNETIC CONTROL OF INDUSTRIAL MOTORS

By Gerhart W. Heumann, industry control department, General Electric Co.; 706 pages, 6 by 9 inches, clothbound, published by John Wiley & Sons Inc., New York; available from AUTOMATION, *$9.50 postpaid.*

Since the first edition of this book appeared, numerous changes have taken place in the design of control systems and components, reflected in this new second edition. Included in the new material is data on adjustable voltage and regulating systems, particularly with regard to rotating and magnetic amplifiers. Care is also taken to explain the external performance characteristics of all types of industrial motors. Components, devices available to the designer, and basic circuits are discussed as a background for examining widely used general and special purpose controllers.

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CONVEYORS AND RELATED EQUIPMENT

By Wilbur G. Hudson, consulting engineer, 519 pages, 5¾ by 9 inches, clothbound; published by John Wiley & Sons Inc., New York; available from AUTOMATION, *$9.00 postpaid.*

This third edition is expanded approximately 25 per cent over previous volumes, to provide concrete information on all phases of the subject. New material includes fundamental developments of the last three years in belt construction and dynamatic drive control; 1954 costs and designs of silos, bins, and bunkers; dust explosion hazards; developments in boiler-house coal handling and storage; data on hydraulic transportation of coal in pipelines; developments in pneumatic conveying; and recent expansions in the applications of motorized industrial trucks. Typical problems and their solutions are also included.

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MANUFACTURING EQUIPMENT AND PROCESSES

By Charles W. Lytle, professor of industrial engineering, New York University and Arthur F. Gould, associate professor of industrial engineering, Lehigh University; 759 pages, 5½ by 9-inches, clothbound; published by International Textbook Co., Scranton, Pa.; available from AUTOMATION, *$8.50 postpaid.*

Aiming to clarify the technicalities of most basic equipment and processes now used in engineering

shops of the United States, this book places emphasis on the principles that should be understood prior to selecting or operating this equipment. Book is a blend of mechanical engineering and engineering economics and tends to clear away any mystery which might surround technical potentialities of basic equipment and processes. Individuals in a position to make decisions pertaining to machinery will find facts necessary to choose and decide which type of units are best for a given set of conditions and whether or not proposed replacement can be justified.

Government Publications

A Study of Electronic Methods for the Measurement of Small Direct Currents. *Report* PB 113479 *by University of Florida; 77 pages; available from Library of Congress, Publication Board Project, Washington 25, D. C.; microfilm,* $3.75; *photocopy,* $10.25.

This survey of methods for accurately measuring small direct currents includes a description of a new type electrometer circuit for such measurement, using nonlinear capacitors. Special attention is given to problems of reducing drift in dc amplifiers used for such measurement.

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Development of Subminiature High-Temperature Capacitors. *Report* PB 113711 *by U. S. Air Force;* 41 *pages; available from Library of Congress, Publication Board Project, Washington 25, D. C.; microfilm,* $2.75; *photocopy,* $6.50.

Property of self-healing is one of the significant characteristics of Teflon capacitors constructed with silver, copper and aluminum metallized films, detailed in this third interim report from Balco Research Laboratories. Report also describes how accurate measurements of very high dielectric insulation resistance were made with a Beckmann microammeter, and summarizes results of load-life tests at 200C on capacitors of various ranges.

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Industrial Publication

PACKAGING MACHINERY MANUFACTURERS DIRECTORY

Leatherbound, 5 by 7½ inches; loose-leaf form; available from Packaging Machinery Manufacturers Institute Inc., New York; $10.00.

Directory provides information on manufacturers of all types of packaging machinery. It is designed as a simplified reference source. Loose-leaf form will allow supplementary information to be added conveniently. It is divided into three sections for easy reference. One section lists the trade names of equipment and names the manufacturers. Lists of types and manufacturers of available equipment, and another alphabetically arranged list, giving names and addresses of machinery makers and complete information on the machines each one makes, comprise the other two sections.

ADVERTISING INDEX

Aetna-Standard Engineering Co., The 24
Alden Elstrom Associates 20
Allied Radio 111
Allied Steel & Conveyors, Inc., Allied Automation Division 117
Alvey-Ferguson Co., The 113
Assembly Products, Inc. 110

Bliss, E. W., Co. 22, 23
Buschman, E. W., Co., The 109

Century Hydraulics, Inc. 101
Clark Controller Co., The 2
Cutler-Hammer, Inc. ..... Back Cover

Doepke, Chas. Wm., Mfg. Co., Inc., The 126
Durant Manufacturing Co. 119
Dyken Mfg. Co., Inc. 20

Eagle Signal Corporation 15
Erickson Tool Co. 128
Executive Services 110

Feedall Machine & Engineering Co. 99
Ferguson Machine & Tool Co., Inc. 16, 17

Gast Manufacturing Corporation 101
Giffels & Vallet, Inc. 77

Hamilton Automation, Inc. 111
Hale & Kullgren, Inc. 24
Hannifin Corporation 119
Hartford Special Machinery Co., The 95
Herrmann, Dr. Roy, Organization, The 118
Holtzer-Cabot Divisions, National Pneumatic Co., Inc. 11
Hughes Research & Development Laboratories 19
Hydraulic Press Mfg. Co. 105

Jefferson Corporation, Swartz Tool Products Division 1

Kendall, George H. 118

Lansing Stamping Co. 101
Lipe-Rollway Corporation 93
Lowe, White & Co. 118

McKay Machine Co., The ..... Inside Back Cover

Master Electric Co., The 5
May-Fran Engineering, Inc. 102, 103
Mead Specialties Co. 7
Mechanical Handling Systems, Inc. 81
Midwestern Instruments 89
Miehle Printing Press & Mfg. Co., Star-Kimble Motor Division 13

National Pneumatic Co., Inc. 11

Pioneer Engineering & Manufacturing Co., Inc. 87
Planet Corporation 85

Standard Electrical Tool Co., The 21
Star-Kimble Motor Division, Miehle Printing Press & Mfg. Co. 13
Swartz Tool Products, Division of Jefferson Corporation 1

Thulin, Woods & Isensee 118
Tomkins-Johnson Co., The 97

Waterman Products Co., Inc. 112
Wean Equipment Corporation ..... Inside Front Cover
Wheeler Associates, Inc. 118
Wilson, Adrian, & Associates 118
Wollensak Optical Co. 123